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DEFLECTING ARMOR,*

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The construction of war ships has within the last forty years undergone many changes; among these have been the abandonment of sails as a sole means of propulsion, and the substitution of steam as the chief motive power, the application of armor as a means of defense, and the change from wood to iron as the material of construction. During the era of sails the vessels of our navy were unexcelled for speed, handiness of movement, gracefulness of form, and for all the qualities attainable by vessels propelled by means of sails. The advent of steam found the art of building sailing vessels in a highly advanced state; the materiel of our navy was probably at that time more effective, in proportion to its size, than that of any other country. In the introduction of steam our government took a leading part, so that at the outbreak of the civil war we had a fair proportion of steam vessels, as compared with other nations; but, unfortunately, a large part of them were of too great draught for the service then required. The large screw frigates of the Wabash class, the large side-wheel steamers of the Susquehanna class, and the sloops of the Hartford and Iroquois classes, were all of too great draught to render the most efficient service. The larger vessels

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could only enter one harbor south of Fortress Monroe, that of Port Royal, where two of them, the Wabash and Susquehanna, assisted by some other lighter vessels, mostly improvised from the merchant service, proved the efficiency of steam vessels, armed with shell guns, against land batteries, when there was sufficient water to permit them to come to close quarters, and keep under way at the same time. If, at the outbreak of the rebellion, the government had been in possession of fifteen or twenty ships of the double-ender or twin screw classes of vessels, of one thousand, or twelve hundred tons displacement, drawing not more than eleven or twelve feet of water, and armed with the shell guns with which Farragut won his victories, it is more than probable that the duration of the war might have been much contracted, for the ports through which supplies were afterwards introduced could at that time have been easily captured. The shoal water of the southern harbors more effectively defended them than the batteries they contained, for wherever the depth of water permitted us to bring our shell guns to bear at close quarters, the enemy were speedily put to flight. Therefore light draught is one of the first essentials for vessels intended to defend our own coast, or to operate against a foreign country.

Defensive armor for war vessels was first brought into practical use, in modern times, by the French during the Crimean war, in an attack on the Russian forts at Kinburn, October 17, 1855, where three floating batteries, armored with four and one half inches iron plates were brought into action; one of them, the Devastation, was said to have been struck sixty-seven times with shot, with no other result than to indent the armor at the most one and a half inches, but ten men were killed and wounded by projectiles which entered the ports. Previous to this period guns had been made, not to obtain great penetration, but rather to throw large projectiles at a low velocity, producing a smashing effect, detaching great quantities of splinters from the wooden sides, and spreading death and destruction in their flight. High velocity, which implies great penetration, was not desired, as such projectiles cut clear holes through wooden vessels, and detached far less splinters then those endued with less energy. The range of these shell guns was then sufficient for the purposes of combat between ship and ship: for it would be very difficult to strike an object from an unstable platform beyond their effective range; therefore long range guns were not made. The French laid the keel of La Gloire, the first sea going iron-clad, in 1858; in this vessel the entire

hull was enveloped in defensive armor of four and one half inches thickness; the British followed with the Warrior, armored with the same thickness of iron, but, owing to the greater length of the vessel, the armor was confined to the central part of the ship. The La Gloire constructed with a wooden hull has long since gone to decay, while the iron hull of the Warrior with no other repairs than those necessary for her preservation, such as painting and scraping, is apparently as sound to-day as when she was launched, showing the superiority of iron over wood for the construction of ships.

Neither the La Gloire nor the Warrior were launched until 1862, when Ericsson's Monitor astonished the world by her memorable conflict with the Merrimac; presenting the novel sight of two vessels armed with the heaviest naval ordnance of the day, discharging their projectiles at each other, for a considerable period of time, at very close quarters, without either being able to do the other any serious injury. In the construction of the Monitor her designer probably put vertical armor at once into the best form [illegible] to put it for a coast defense vessel; improvements have been made in matters of minor detail, but the general form of the type is identical with the original.

Against the ordnance of the period, vertical armor as applied in the monitors was an efficient protection, and it was seen that guns of greater penetrating power than those then in existence were necessary to pierce it; that the short shell guns of large calibre, throwing projectiles at a low velocity, although admirably adapted for conflicts between wooden ships, were not suited for this purpose, but that guns of increased length in proportion to their calibre, enabling them to burn a larger quantity of powder, and throwing elongated projectiles at a high velocity, thereby concentrating a great amount of energy to overcome the resistance of a small area of armor, was what was required. Accordingly such guns were made, and the vertical armor was readily penetrated; the armor was thickened, but guns were made which pierced it.

The conflict between guns and armor has gone on for nearly twenty years, with almost unvarying success on the part of the guns; until, with the limit of power by no means attained, guns are now made capable of piercing three feet of iron armor. The weight of armor now easily penetrable is so great that even if the attempt to protect with it is confined to special parts, none but the largest vessels can carry it. In this state of affairs a resort has been had to iron plates faced

with steel, and to plates of pure steel, by which the thickness required has been somewhat reduced, but even with compound and steel armor the ascendancy of the guns is complete, when the armor is arranged vertically. As we have the same materials, iron and steel, out of which to make both guns and armor, it may be well to inquire why the victory has always been on the side of the guns? The answer is, we have endued our guns with a very large time element, while this most important factor is almost entirely wanting in vertical armor.

In speaking of the time element in relation to armor and guns, we should remember that in physics no period of time is so minute that it may not be still further divided; measured by the impression on our imperfect senses, the times of explosion of nitro-glycerine and gunpowder are of equal duration, but measured by their respective effects, we know there is a great difference, and that the time occupied in the combustion of gunpowder is of considerable duration when compared with the time of explosion of nitro-glycerine.

Gunpowder is a mere mechanical mixture in which the chemical equivalents are heterogeneously mixed and have to be changed from the solid to the gaseous state by heat before they acquire the mobility to seek their affinities; its combustion is progressive, one part combining and heating the other to the gaseous state that it may likewise combine; but all taking place in a period of time too minute to be appreciated by our senses. It is this element of time in the combustion of gunpowder that gives it its great value as a propelling agent. In nitro-glycerine, the explosive action is entirely different; as it is a chemical combination in which the molecules are systematically arranged side by side with their affinities, with the distance between them infinitely minute, ready to clash together instantaneously, with terrific energy, on the first vibration, all combining at once. In the explosion of gunpowder the combination of the elements is gradual and progressive, producing a propelling action by means of an elastic pressure; while the combination of the elements of nitro-glycerine is instantaneous, producing an impactive blow.

If we should charge our guns with nitro-glycerine we would shatter them to fragments, as well as the projectiles themselves. These would acquire but little power, as the explosion is so sudden that no time is given the shots to accumulate energy, before the guns are ruptured; but gunpowder, in a comparative sense, burns gradually and progressively, imparting increments of energy to projectiles the whole distance travelled from the breech to the muzzle of the gun. Immense energy is

imparted to projectiles without injury to the gun, by propelling them from the breech to the muzzle thereof by means of an elastic gas at as high a pressure as the gun will bear without rupture; the energy is imparted gradually, being accumulated from strains upon successive sections of the length of the gun, and stored in the shot during the time it is traversing that distance.

When we fire a shot against a vertical armor plate, we attempt to resist this immense energy upon the sharply defined area of the shot instantaneously; or during the time the shot at its high velocity is traversing the almost inappreciable distance iron will stretch before breaking. This time is infinitesimal, and the action of shot against vertical armor is in its time element analogous to the impactive explosion of nitro-glycerine. If we cannot use nitro-glycerine to impart energy to projectiles on account of its lack of a time element, we should not attempt to resist the enormous energy imparted to projectiles, through the time element of slow burning gunpowder, by the impactive resistance of vertical armor. By firing a shot against a vertical armor-plate we can readily pierce a thickness of armor much greater than the sides of the gun from which the shot was fired.

If, for the sake of theoretical illustration, we take two guns alike, and fit in the muzzle of one a piston, gas tight, and confining a high pressure of an elastic gas, and if we load the other gun with a charge of powder and a shot, and fire the shot directly against the piston, the energy of the shot would be gradually absorbed during its passage down the bore; the pressure of the gas increasing before it inversely as the space occupied—according to the well known law of Marriotte—until it is brought gradually to rest and shot out again, without injury to the gun fired into: all taking place in a period of time inappreciable to our senses, but of considerable duration when compared to the period of impact of shot against vertical armor. The operation is simply reversing the conditions under which energy was originally imparted to the shot; and no greater strain would probably be put on the gun fired into, than on the gun from which the shot was fired.

If we present a rigid, unyielding resistance to projectiles we invite destruction to our armor; if we present a yielding, elastic resistance we absorb the energy of the shot gradually, without injury to the armor, in like manner as it was imparted to it without injury to the gun. If a blacksmith were to use an anvil of very light weight, mounted on springs, his impactive blows would produce but little effect.

While serving on the Mississippi river, under Admiral Farragut,

during the civil war, the writer observed that shot fired from the bluffs, striking the decks of our vessels, were turned from their course by the most trifling obstacles, and passed on with apparently undiminished energy; at an acute angle the wooden deck itself was sufficient to deflect shot, while great resistance often failed to arrest them by direct impact. This led to the observation of the ricochet shot, which is simply a shot oscillating between two opposing forces, the upward deflecting action of the water's surface and the downward draw of gravity; such a shot on a smooth sea will travel for miles, performing many deflections; the initial energy being absorbed by the resistance of the air, the deflections, and the final plunge. From the great distance travelled, and the great number of deflections, we may form some idea of the small resistance required to deflect shot, as compared with that necessary to arrest them by direct impact.

That a gentle current of air blowing against the side of a shot will swerve it from its course, is a fact well known to all riflemen; in this case the shot is not deflected by encountering a resistance at its forward end, but the lateral divergence from a direct line is caused by the pressure of the air against its side; the curve described being the resultant of the initial energy of the shot and the lateral pressure of the air; showing how slight a force will swerve a shot from its course, when it acts through a comparatively great period of time; or, what is the same thing, while the shot is traversing a comparatively great distance.

In the Peruvian ram Huascar the armor of the turrets consisted of iron five and one half inches thick, except around the ports, where it was seven inches in thickness, backed by fourteen inches of teak; the side armor consisted of four and one half inches of iron, backed by fourteen inches of teak. The guns used against her were comparatively light. All shot striking near right angles to the armor's surface pierced it; all striking at an acute angle glanced off, merely indenting the armor. The armor was arranged to resist shot by direct impact but the only protection obtained was by deflection.

The conclusions are:—

1st, Projectiles from modern guns can pierce the thickest armor a ship can carry, provided they strike at nearly right angles to its surface.

2nd, Shot striking armor at an acute angle glance harmlessly off, merely indenting the armor.

3d, The more acute the angle of impingement, the less thickness of armor required to deflect the shot.

4th, Armor is at present arranged vertically to arrest or resist shot by direct impact, while the only protection obtained is by deflection.

5th, It is therefore proposed to arrange the armor at an acute angle, to deflect the shot from first intention, and make no attempt to resist the irresistible.

In disposing armor to deflect shot great attention should be paid to its elasticity—which simply means a time element—for the more gradually the direction of the shot is changed, by creating an elastic resistance under them, the less injury the armor will receive.

Elongated projectiles attain their great penetration by concentrating the energy due their great weight and velocity upon the area of their cross section. By deflecting armor the ends of such shot can be easily turned, so as to present the much greater longitudinal section to the armor, which will greatly facilitate deflection. When a shot strikes a deflecting surface it makes a spoon shaped dent, the length of which indicates a part of the time element of the armor; but as the armor is elastic, and yields bodily to the shot, another increment of time is added.

By the use of comparatively light plates of a good quality of low steel, disposed at an acute angle, we distribute the impact of the shot over a larger surface of armor, gain the mechanical effect of the inclined plane, infuse a further element of time by means of an elastic resistance under the shot, thereby deflecting them from the armor's surface, after absorbing only the small portion of energy necessary to turn them slightly from their course; permitting them to pass on and expend their remaining energy elsewhere.

While the action of projectiles against vertical armor is analogous in their time element to the impactive explosion of nitro-glycerine, their action against the acute deflecting armor described will be analogous to the more gradual explosion of gun powder, and, with it, as we have the same materials out of which to make both armor and guns, armor can be made equal in resistance to the power of guns, as the armor absorbs but a portion of the energy with which projectiles are endued.

The application of the principle of deflection as a means of defense is probably coëval with primitive man. The shields of many tribes of savage people of the present day are made of a curved form, that the weapons of an enemy may glance from their surfaces; the shields of the ancient Roman soldiers were of a similar form; so that an adversary's battle-axe would glance from them, and before it could be raised again the short sword from behind the shield had done its work.

The application of the principle of deflection to resist naval ordnance is by no means new; an American inventor, Thomas Gregg, obtained a patent for an armor-plated vessel, with inclined sides, as early as 1814; this shows a far better appreciation of the requirements of a vessel to resist ordnance than any of the recent constructions of the great naval powers of Europe. The Confederates made use of the principle in all their armored vessels; as did likewise our government in many of the gun-boats built for service on the Mississippi, and other western rivers. But, in all these constructions the entire hull was enveloped in defensive armor; a method which will not admit of angles of impingement sufficiently acute to resist modern ordnance, without reducing the margin of buoyancy to such a degree as would render the vessel liable to sink on the admission of a comparatively small amount of water.

In order to present angles of impingement sufficiently acute to deflect shot, stored with the immense energy imparted by modern guns, it is proposed to protect the water line by one device, and the guns by another above it, with a free and unobstructed passage for shot—so far as armor is concerned—between the two; as the less resistance offered, the less injury received.

The armor defending the water line is to consist of an Interior Convex Deflecting Shield, which is to be secured to the sides of the vessel four or five feet below the water line, and to extend across from side to side in the form of an arc of a circle, or some approximate curve; rising amidships some two or three feet above the water line, and dipping at the stem and stern some six feet, or more, below it. The position of this shield, as regards the water line, will vary with the size of the vessel, but it is to be of such a form, and to be so placed within the hull, as to present a practically constant angle of impingement to a horizontal shot at the water line, in all the positions the vessel may assume in rolling and pitching, and that so acute as to make penetration impossible with a very moderate thickness of armor. As the interior shield rises amidships considerably above the water line, it protects the vital far side of the vessel, where projectiles at their exit do the greatest damage.

In order to secure the buoyancy and stability of the vessel, it is proposed to pack the cellular sides above and below the shield with cotton chemically prepared to resist fire, which will by its elasticity close up shot holes as fast as made, and thereby prevent the entrance of water; and if the space between the convex surface of the shield

and the deck above it was divided into water-tight compartments, and packed with ship's stores, put up in metallic canisters of rectangular form, so as to stow closely, and to exclude water, the buoyancy and stability of the vessel would be still further insured. Or this space may be packed with cork or other buoyant substance, so that although the vessel above the interior shield is completely riddled by shot, her buoyancy and stability will remain intact.

Shot striking the side of an iron or steel vessel fitted with such an interior deflecting shield and with cotton packed sides would make a clear-cut hole at their entrance which would be immediately closed by the elastic cotton, and, impinging against the shield at an acute angle, this shot would be deflected upward and outward, far above the water line on the other side.

It is to the far side of a vessel that projectiles do the greatest damage; shot fired from a distance and striking a vessel near the water line would be carried considerably below it on the far side by the curve of their trajectory. Projectiles entering the side of a vessel above the water line are apt to be deflected downward, by encountering any obstacle, and make their exit below it on the other side.

The heavy percussion shell now in use, each one of which is in itself a mine, will do great damage to the far side of a vessel, where their exploding cones will doubtless blow out entire sections of plating, and admit great volumes of water; while solid shot striking the transverse frames will also be apt to displace entire plates from the far side below the water line. Against such missiles, the cellular system of construction alone, is entirely inadequate to give protection; but in combination with the interior deflecting shield, complete protection for the water line can be obtained, under all ordinary conditions; but no form of armor can protect a vessel from projectiles fired at very close range from guns depressed.

The deflecting action of the water's surface, and the fact that elongated projectiles fired from rifle guns at an elevation strike the water butt first and tumble end over end, will protect the near side of a vessel below the water line; while the far side would be most effectively protected by the interior deflecting shield described. The flat trajectory of the projectiles of modern guns will enable them to strike a target of a given vertical plane at a great distance, but a target of a horizontal plane at a like distance would be very difficult to strike; while curved fire from land batteries will be very effective in defending narrow channels against the passage of ships, where the range is

known, such fire would be a mere waste of ammunition if the guns were on the unstable platform of a ship rolling at sea, and directed against another vessel.

The cellular system of construction, in combination with an under water armored deck, situated a foot or two below the water line, with water excluding stores packed above it, will not give the same measure of protection as the interior shield rising considerably above the water line amidships, and thereby protecting the vital far side; for the heavy shell now in use would soon blow out the stores, as well as the side of the vessel confining them, and admit great volumes of water. This would heel the vessel over so that projectiles would strike the under surface of the armored deck, and be deflected downward through the bottom of the vessel, probably exploding as they went. A flat armored deck situated but a short distance below the water line, would be liable to receive shot under it as the ship rolled, and, instead of being a safeguard, would be a positive source of danger—to a vessel fitted with it—from the downward deflection of projectiles. With the ship's stores packed in the water-tight compartments above it, the interior shield practically takes up no more room than its air space, and is specially adapted to vessels of light draught, such as we require, as it rises considerably above the water line amidships; while the armored deck being entirely below the water line, would, in a light draught vessel, greatly encroach upon the space necessary for the boilers and machinery. The interior deflecting shield, with the cotton-packed sides, for closing shot-holes, and the water-tight compartments above it, stowed with ship's stores, put up in rectangular metallic canisters to pack closely and exclude water, form a combination of elements for the end in view which it would seem difficult to excel.

It is proposed to protect the guns, and the men to serve them, in deflecting turrets, or double convex gun shields, the surfaces of which present angles of impingement so acute as to deflect shot with comparatively light armor. These deflecting turrets may be supported above the interior deflecting shield in different ways. One plan, illustrated in fig. 1, is to make the deflecting turrets in two parts; the lower part is securely attached to the interior shield B, being supported above it on a stout central cylindrical column C, which should be made hollow to admit of the passage of men and ammunition from the magazine below the water line; as this column is very short, it can easily be made sufficiently stout to resist shot; besides its cylindrical form makes it an excellent deflector. The deflecting turret is

also supported on the concentric cylinders, D, D^1, D^2, D^3, made of sheet metal, which will render an efficient support but interpose no substantial resistance to the passage of projectiles through them; and therefore are not liable to be shot entirely away.

An intermediate deflecting plate X is placed between the two shields to prevent shot from being deflected from one shield against the other at a penetrating angle. The lower part of the deflecting turret is cut, and the upper part rests on the anti-friction wheels, F, F^1, F^2, F^3, Figs. 1 and 2, and revolves with its contents on circular tracks on the stationary lower part.

In view of the great length now given to guns to obtain the penetration required, it is proposed to protect the ends extending beyond the deflecting turrets with the auxiliary deflectors W W, Fig. 2, which are of convex cross section, made of very heavy sheet metal, and secured to the guns by means of bands. If one fourth the weight of metal used as armor to protect guns was put into the guns themselves in a deflecting form, the guns would need no other protection.

The space between the interior deflecting shield protecting the water line, and the deflecting turrets protecting the guns and the men to serve them, is to be as free and unobstructed for the passage of shot as an adequate support of the deflecting turrets and the requirements of a sea-going vessel will permit. As shot follow the direction of the least resistance, all the parts of the vessel contiguous to the deflecting surfaces should be made as light and penetrable as possible; so that projectiles are not bound up against the armor thereby penetrating it.

Figs. 3 and 4 illustrate the general plan of a vessel armored with the interior deflecting shield, for the protection of the water line, and double convex deflecting turrets, for the protection of the guns and the men to serve them. The deflecting turrets are here supported beneath the interior shield, each on a stout central column or spindle C; which is stepped in a large casting D, resting on the keelson of the vessel. The castings constitute hydraulic presses, and the spindles, plungers; upon these the turrets are supported on hydrostatic pressure, which admits of great facility of rotation. The deflecting turrets, supported above the interior deflecting shield on four stout cylindrical columns, a and b, which revolve with them, one immediately under each gun, and one at the breech of each gun, through which the ammunition is elevated from the magazine beneath the interior shield. When the guns are bearing on an enemy, the rear col-

umns are behind, and covered by the front ones, and as they are very stout, and of cylindrical form, they are excellent deflectors, and therefore could not be shot away.

The deflecting turrets may be supported above the interior shield upon one central cylindrical column, with an aperture through it sufficiently large to admit of the passage of ammunition and men. These supporting columns can easily be made sufficiently strong to resist shot, and it is probably the best form of support of the three described. Composition anti-friction wheels E, E, Fig. 4, set in the edges of the circular hatches through the interior shield give the deflecting turrets an efficient lateral support.

The interior shield presents a practically constant angle of impingement to horizontal shot in all the positions the vessel may assume in rolling and pitching; while the deflecting turrets will present a constantly varying angle as the ship rolls; when, however it is considered that the deflecting turrets deflect laterally as well as vertically, and that the varying angle is very small, except through the center of the turret, the danger of penetration by an increasing angle will be found not very great.

The armor, forming the interior shield, is constructed in two layers, plated diagonally to break joints, and secured together by means of taper rivets with counter-sunk heads. As great rigidity against shot is not desired, but, instead, a certain degree of elasticity, no framing will be required to support the interior shield, other than one central longitudinal, and the transverse bulkheads, necessary to divide the space under it into the desirable number of water-tight compartments.

The interior shield, extending the length of the vessel and beyond the bows to a ram, tied in by the chords of its arc, and supported on the longitudinal and transverse bulkheads, in combination with the ship's cellular bottom and sides, forms a ram and a vessel of unprecedented efficiency and strength. The weight of the interior shield is distributed over the vessel in almost direct ratio to the ability of the different parts to bear it, and therein differs advantageously from vertical armor, which throws great stress on special parts, and is a source of weakness to a vessel: while the interior shield is an element of immense strength, as it gives a rigidity to a ship which could not be better attained if the material was disposed for that purpose alone. A point which should not be lost sight of is the great efficiency of such a ship as a ram; when a vessel is struck which is moving across the bows with a high velocity, the wrenching effect is such as

few ships built as rams can sustain; but such a vessel as described possesses the strength in an eminent degree to resist such a transverse strain.

At all places where openings are made through the interior shield for hatches, smoke pipes, ventilators, etc., the armor should be brought up square, or level all around with the highest part of such opening, and where the angle has to be made more obtuse, the armor should be thickened, as compensation; and all such openings should be defended by heavy gratings. The armor around the large circular hatch Fig. 4 is squared with the crown of the shield, and thickened where the angle above the water line is made more obtuse; this gives the interior shield the appearance of having plane sides, which is owing to the section being made through the diameter of the hatch; at all other points the shield conforms to the arc of a circle, as shown by the dotted lines.

Elongated projectiles fired from rifled guns at an elevation maintain the elevation of the gun in their flight, as the longitudinal axis of the shot remains parallel to the axis of the bore of the gun from which it was fired. The curve of the trajectory is the resultant of two forces—the initial energy of the shot and gravitation; and the latter force acting on each end of the shot alike, it falls bodily; consequently, such shot would strike the interior shield in a position favorable to deflection, as shown by figure 5.

In order to guard deflecting armor against square headed punching shot, which might otherwise penetrate it, it is proposed, if found necessary, to cover its surface with a system of auxiliary sliding deflectors, made of light sheet metal, and slightly attached by screws, or tap bolts, the object being to ride projectiles on them up the convex surface of the armor. These sliding deflectors may be of several forms. In Fig. 6, they are represented as beveled on all four sides, so as to freely slide over each other; in Fig. 7, they are represented like shingles on a roof, only in reverse order; Fig. 8 illustrates sliding deflectors of the same general form as Figure 6, but dished, so as to stand off from the armor and leave an interstice. These sliding deflectors would be carried away by shot striking them; but, as it is proposed to have no man exposed during action outside the armor, no material damage would be done by the upward flight of the deflectors, or of projectiles deflected from the interior shield. The sliding deflectors represented by Fig. 8, which are dished, and stand off from the armor's surface, would act as stiff springs to projectiles

striking them, and would add to the elastic resistance under the shot. This would greatly facilitate deflection, by turning the point of the shot and bringing it sidewise against the armor, thereby greatly increasing the area presented. The more gradual the contact between shot and armor the less injury the armor will receive, for it is by the concentration of energy on a small surface that armor is pierced.

A shot striking one of the dished sliding deflectors, Fig. 8, the moments of time and augmenting resistance under it, may be divided into four. 1st, time gained and pressure augmented under the shot from the first contact until the under surface of the sliding deflector is pressed down against the armor. 2nd, time gained and pressure augmented under the shot while it is riding on the deflector up the convex surface of the armor. 3rd, time gained and pressure augmented under the shot while the armor is yielding locally to it. 4th, time gained and pressure augmented under the shot by the armor yielding bodily to it. These increments of time and resistance blend, and run into each other, and are too minute to be appreciated by our senses; but during the period, the center of gravity of the shot describes a curve which clears it of the armor's surface. The length of this curve, beginning at the point of first contact and ending where the shot flew off at a tangent, indicates the time element of the armor; this may be very short when compared with the length of the gun, but as equal increments of energy are not imparted to shot the whole length of the bore, the greater portion being imparted at the breech end, and as the shot still retains the greater part of its energy after it is deflected, it is evident that deflecting armor does not need a very great time element.

The British Admiralty have made experiments with deflecting armor, with a view of ascertaining the least possible angle at which square-headed punching shot would bite, and have found that the best Whitworth and Palliser shot under the most favorable circumstances could not be made to bite at a less angle than eleven and one half degrees. The square-headed shot are very wild in their flight and therefore not likely to come into general use; but if they are used, the sliding deflectors will turn their ends and present their sides to the armor, thereby depriving them of their penetrating power.

In view of the deadly efficiency attained by modern machine guns, and, as in future naval warfare the gun ports will doubtless be the targets upon which these destructive engines will be directed, it has become desirable to pass the guns through the armor by the least pos-

sible opening. Therefore it is proposed to mount each gun between two beams, or girders I, I, Fig. 2, upon which they are to slide back and forth on four lugs L, L, made on the gun, or secured to it by bands, and extending through slots in the beams. The beams are joined together at the breech end of the gun, forming a frame which at the muzzle end is attached to the armor by the joints J, J, on a line with the passage of the gun through the armor; this admits of elevation, depression and recoil, through the smallest possible opening; so that when the gun is run out the armor fits closely around it.

The guns are to be elevated and depressed by means of the hydraulic presses K, K, the rear end of the frame being elevated and depressed with the gun, which has no trunnions, the joints J, J, serving instead. The recoil of the guns is to be received on the hydraulic recoil presses M, M, which also serve to run the gun out to fire, and both in and out, whilst exercising. Upon each gun frame there is an attachment extending out from the gun for the support of a radius bar, one end of which is attached to the frame, the other end being secured to the breech block of the gun; when the gun is run out, the radius bar pushes the breech block into the gun, ready to fire, and stands at right angles to the axis of the bore; when the gun is run in, the radius bar draws the breech block out of the gun ready to reload. The object of this arrangement is to draw the breech block out of the gun by means of the recoil. The guns as shown recoil 2 feet 3 inches, and the breech block does not commence to open until the gun has recoiled a foot. The Krupp breech block draws easily from the gun after it is started, and the radius bar will exert great power to start the block; if one of the eyes in the bar is made elliptical, so as to give a little play to the bolt, the bar would act with a jerk, which would prevent the block sticking fast.

The guns permit of elevation of ten degrees. The ammunition, which for convenience is assumed to be fixed, is to be elevated from the magazine, and pushed into the tilting pipe P, Fig. 4, where it is caught by spring catches, the elevator retiring down the tube. The pipe P is mounted on trunnions and swings upon a crane. The gunner then swings the charge by the crane to the rear of the gun, turns the pipe over into the horizontal position, as shown by the dotted lines, and by a thrust of the hydraulic rammer R, pushes the charge into the gun; the gun is then run out, and fired, the radius bar, actuated by the recoil, opening the breech for another charge, which has by this time been elevated and swung into position in the rear of the gun.

Deflecting turrets may be made in which the guns are mounted en barbette, with the hydraulic and loading gear protected inside. The guns are mounted in frames, jointed at their forward ends—similar to those previously described,—the frames forming a part of the top of the turret, into which the breech ends of the guns are set. This form of deflecting turret possesses the advantage of placing the weight of armor lower, thereby increasing the stability of the vessel. The guns are elevated and depressed by means of hydraulic presses inside the turret; and they slide back and forth on lugs, which in this case are under them; the recoil is received on a hydraulic press behind the forward lug, and under the gun. The same general form of loading apparatus and breech movement can be applied as described above, the guns being loaded by depressing the breech.

As the loading apparatus of all the deflecting turrets revolves with them, the operations of loading and firing can go on uninterruptedly without the necessity of turning to a loading station after each discharge, and then having to seek the target again; The loss of much valuable time, at a critical period, is by this arrangement avoided. With the loading apparatus and automatic breech movement described the guns can be loaded and fired with great rapidity; and while a heavy armor-clad is damaging the light upper works of a vessel protected with deflecting armor, the latter could with the appliances described, drive shot after shot in rapid succession through her opponent's vertical armor, and by the fragments displaced, transform her very means of defense into deadly missiles of destruction.

As to the material of which to construct the hulls of war vessels there can be no hesitation in regard to the choice, iron or low steel being the materials par excellence. Wood as a material of construction was abandoned by all European nations as early as 1871. In the merchant service high authorities assert that the saving in weight effected by the change from wood to iron is as great as thirty or forty per cent. At the present time no European nation constructs war vessels of wood, greater strength being attained with far less weight, by the use of iron, and the superiority does not consist in greater strength alone, but in far greater durability. The wooden vessels now in service require extensive repairs after each cruise, costing immense sums of money, and requiring considerable periods of time, during which the service of the ship is lost to the country. But it is not only the loss of the use of the vessel when needed, and the excessive cost of repairs which we incur by building them of

wood, but every vessel so built carries a useless weight of from thirty to forty per cent. of the weight of her hull, which might be applied to give her additional powers of offense, defense, and mobility.

One of the first requisites of a modern war ship is high speed, and for this the necessary rigidity of hull cannot be obtained if wood is the material used; nor can the cellular system of construction, that great safeguard of buoyancy and stability, be applied except in iron or steel vessels; besides the stowage capacity of such ships greatly exceeds that of wooden vessels. By the use of steel as the material of construction the same strength of hull can be obtained with one fifth less weight than if iron was the material used. Ex Engineer-in-Chief J. W. King, U. S. Navy, says in "The War Ships and Navies of the World," "Formerly the greater first cost, and the doubtful character of the metal produced, constituted serious objections. Now however the manufacturers have placed on the market steel specially adapted to ship-building—a metal so mild, as to bend rather than break, in case of severe strain, and yet possessing a higher tensile strength than wrought iron, and approximating iron in first cost. Such an access of ductility and tensile strength is secured by the use of this steel, that Lloyds allows a reduction of twenty per cent. in the thickness of plating and frames of steel vessels. The plates of this metal are much less likely to be weakened by punching closely spaced lines of rivet holes, and as they are equally strong crosswise and lengthwise, instead of having their strength like iron in the direction of the fibre only, they are obviously more to be depended on. The absence of lamination in steel plates, and their greater smoothness, are other advantages possessed by them over iron." Greater strength can be obtained with from thirty to forty per cent. less weight if iron is used to construct the hull than if wood is the material employed, and steel gives a further gain of twenty per cent. over iron; therefore steel should be the material chosen, but great care should be exercised in its selection. Iron and steel are capable of producing vessels—if built on the cellular system, of far greater buoyancy than wood; but no matter of what material a ship is constructed, she could not long be kept afloat when subjected to the fire of modern ordnance, if her water line is not protected with defensive armor. We hear much of the buoyant qualities of the old wooden frigates, but if they had contended against ordnance like that now in use, their buoyant qualities would not be so highly rated.

Recent experiments made by Herr Krupp at Meppen go to show that great penetration can be obtained by guns of comparatively small calibre. A gun weighing but 3.9 tons of 6 inch calibre, throwing a shot of 112 lbs. gave a total energy at the muzzle of 2,170 foot tons, and at 2,150 yards of 1,306 foot tons, which it is estimated at that distance would pierce twenty inches of armor. Experience has proved that in small arms the greatest efficiency is obtained by using the smallest calibre that will effect the purpose; by diminishing the size of the projectile the number which a man can carry is increased, and it is argued that the bullet of the United States standard rifle .45 inch calibre will kill a man just as effectually as one of much greater size. This being true of small arms, why will not the same rule apply to naval ordnance, the object of which is to pierce an enemy's armor? Great penetration is obtained by increasing the length of the gun—in proportion to its calibre—and the size of the powder chamber, by which a much greater quantity of powder is burned, and a higher velocity imparted to the projectile.

A gun of 10 inch calibre can be made, firing a shot of 500 lbs., which will pierce a far greater thickness of armor than any ship can carry; such being the case it would seem to be unwise to make guns of such enormous dimensions as is now being done by some of the European nations, throwing projectiles of a ton weight or more. All the penetration necessary can be obtained with much less calibre, and therefore it would seem to be good policy to restrict the size of guns to that calibre which will pierce the required thickness of armor, and to fire a greater number of shot from guns of less size.

Guns of such great size of bore are not desirable, from the fact that to attain equal strength, with smaller calibres, their proportions have to be greatly increased; besides smaller guns can be operated with much greater rapidity. For cruising vessels doubtless guns of 6 or 8 inch calibre, if made of sufficient length, and capacity of powder chamber will be found to give all the penetration necessary. In addition to heavy guns, for piercing armor, all vessels should be armed with heavy machine guns; the larger size discharging percussion shell of two inches or more in diameter, and capable at ordinary ranges of piercing the side of an unarmored vessel or even light vertical armor; these should be operated by vertical shafting, driven by steam power from beneath the interior shield. In large vessels four such guns, two large, and two small, could be mounted in one of the deflecting turrets; in the lighter vessels they could be mounted on V

shaped deflecting shields, and would be very efficient weapons against torpedo boats.

The deflecting armor proposed possesses the advantage of great cheapness and simplicity of construction over the massive vertical armor now in use; any ordinary rolling mill being able to furnish the comparatively light plating required, and the appliances of any common machine or boiler shop serving to fit them together. No enormously expensive plant of machinery is required to roll and bend the heavy plates, and then to plane their edges so as to fit together, as in the case with vertical armor.

For coast defence I would suggest an armored vessel with a length over all of two hundred and fifty three feet, breadth of beam fifty five feet, draught of water sixteen feet, displacement four thousand tons, grate surface three hundred and eighty square feet. This will give a speed of about twelve knots per hour, and the draught will be sufficiently light to enable the vessel to enter the principal harbors on our coast. Four twenty-two ton breech-loading guns would be carried in two of the deflecting turrets described. The turrets are arranged so that all four guns may be fired directly ahead, three directly astern, or all four broadside. Quarters for the officers and crew are provided for by two houses on deck.

The important part which heavy machine guns will take in future naval warfare, will doubtless curtail the usefulness of unarmored vessels. These guns can be made to throw almost continuous streams of small percussion shell capable of piercing the sides of unarmored ships, or even light vertical armor, at ordinary ranges, so that it will be impossible for life to exist above the water line, on board such vessels, many minutes after the opening of a combat. Such ordnance will make armor a necessity for the protection of the men serving the guns; in a like manner the immense power of the heavy guns, firing shell terrific in their effects, will necessitate the protection of the water line in order to keep the ship afloat. Heavy machine guns can be made effective against an unarmored vessel at any range at which the guns of such ship can be advantageously used against armor. Unarmored vessels can be built carrying powerful batteries, with engine power sufficient to make them superior in speed to armored vessels; but if their gunners can be annihilated, and all parts of the ship penetrated by machine gun fire at any range at which her battery can be effectively used against armor, of what use is such a vessel for fighting purposes? She would possess the speed to chase an enemy

down, but would not be able to fight with any chance of success after having done so. Commerce destroyers, to enact the role of the Alabama, need not be fighting ships, for swift vessels from the merchant service can readily be converted into men-of-war for such purposes.

Invulnerability by means of defensive armor, great offensive power in the form of a heavy battery, a high rate of speed by means of great engine power, and corresponding coal capacity, and ability to turn quickly, are four qualities of the highest importance to a war vessel; but it is impossible to combine all these in the highest degree in one ship. A high rate of speed is of the greatest importance to all vessels protected with deflecting armor, as it is vulnerable to plunging shot fired from guns depressed, in the same manner and to the same extent as other vessels; and in order to maintain her superiority the ship should be enabled by greater speed to choose her own position. The much less weight of armor required to give an equal measure of protection, permits of the engine power to give the speed required when contending against vessels armored on the vertical system. Ability to turn quickly to ram, or to avoid being rammed, is another important quality; this implies a vessel of considerable breadth in proportion to her length, and is incompatible with extreme high speed; but as all the important qualities cannot be combined in one ship, it would perhaps in a cruising vessel be advantageous to sacrifice handiness to speed, and to gain the necessary displacement to carry the required weight of armor and engine power by increased length. All vessels except those of the smallest size should be propelled by means of twin screws, which will enable them to be manœuvred with facility; the steering gear of all vessels should be operated by means of hydraulic power, and completely protected either by armor or water.

Invulnerability by means of defensive armor, and a high rate of speed by means of great engine power can only be attained in vessels of considerable size, and for cruising ships of the first class, six thousand tons displacement would not seem to be too great. Fig 3 represents such a vessel, the length of which is two hundred and eighty-eight feet, breadth of beam fifty-seven feet; draught of water twenty-three feet, grate surface four hundred and fifty square feet, horse power four thousand. With a moderate fineness of lines this should give a speed of fourteen knots per hour; but the draught of water might be reduced, and the necessary displacement obtained by increasing the

length, and sufficient power might be added to give a somewhat increased speed.

The system of deflecting armor is applicable to all classes of vessels, light cruisers as well as heavy, but though the former need not be so heavily armored as to interfere materially with their speed, it is assumed that the water line of all ships should be protected, as well as a portion at least of the battery. While the deflecting turrets would seem to be the best form of armor for protecting the gunners of the larger vessels, the guns of the lighter vessels could be mounted on V shaped revolving shields operated through the crown of the interior shield, which would give protection to the hydraulic gear and the men working the guns. These V shaped deflecting shields could be closed at the rear, so as to give protection from small-arm and machine-gun fire all around, but they would only give protection from heavy projectiles from the direction in which the guns were trained. The guns could be kept constantly trained on the enemy, however, and, as it is probable that combats will be much more frequent between single vessels than between a greater number, the shields would give a fair measure of protection with a minimum of weight. A class of swift cruisers could be built armored with a light interior shield placed rather low to secure an acute angle of impingement, and armed with a battery of light breech-loading guns of great length and large capacity of powder chamber, mounted on four or five V shaped shields, placed amidships, with the guns operated by hydraulic gear, and capable with the appliances described of discharging projectiles of moderate size in rapid succession able to pierce the thickest vertical armor. Such vessels if made of sufficient size could be engined with the power necessary to attain high speed, with which they could choose their own position in combat. Or the guns could be mounted on an open deck with a small deflecting shield secured to the breech of each gun sufficient to shelter the one man necessary to work the hydraulic gear and to fire from splinters and machine gun missiles. The guns could be trained by means of stout vertical shafts extending from beneath the interior shield, which would also serve as conduits for the hydraulic power to the recoil and elevating presses. These shields can be made very compact and strong, and of such form as will deflect shot coming from the direction in which the guns are trained and affording protection against all but the heaviest projectiles.

Besides the larger ships, a class of smaller vessels of not more than eight hundred or a thousand tons displacement, drawing not more than

ten feet of water, to be used as rams, could be armored with an interior shield, which would give them great strength to resist the transverse strain to which rams are liable. Such vessels armed with one large rifle, mounted on a V shaped shield, would make very efficient rams and gunboats for defending a great length of coast; their light draught would enable them to enter all ports, and to seek safety in shoal water, in event of being pursued by a more powerful adversary. The interior shield is specially adapted to these light draught vessels; and it qualities are best displayed in vessels of considerable breadth of beam, giving great steadiness of platform for the guns and great stability under sail. The latter quality may be increased by water ballast in the cellular bottom, which also serves to trim the shield for action.

To avoid foulness of bottom all large cruising ships should be sheathed in wood and copper, but for the smaller class of vessels the composite system of construction would seem to furnish the requisite strength and protection with less weight.

All vessels should be sparred sufficiently to keep the sea under sail alone; which is a very important consideration in view of a lack of coaling stations. In Fig. 3, the sail plan of the vessel is illustrated; the vessel is fitted with tripod masts, intended to be unshackled, and lowered on deck on going into action.

Every vessel should be fitted with a series of pipes leading from the different water-tight compartments to the engine room, where they should be connected to a large centrifugal pump, placed high up in the vessel, so that it would not cease working even if the compartment in which it was situated was partly filled with water; these pipes should also be connected with the circulating pump of the condenser, by means of which any compartment could be pumped out, unless the leak was of inordinate amount. Before going into action all the water-tight doors in the lower part of the compartments should be closed, and in order to communicate with the different compartments under the shield without admitting water from one to the other, there should be a gallery or trunk, of sufficient size to admit of the free passage of a man through it, extending the length of the vessel, immediately under the interior shield, on one side of the central longitudinal bulkhead, and communicating with the upper part of each water-tight compartment, by means of water-tight doors. This would enable each water-tight compartment to be entered for inspection without endangering the others; and if the compartments were made air-tight above, as well as water-tight below, and a pipe run into each from a compressing air

pump, any compartment found to be admitting more water than the pumps could free it of, could have air pressure forced into it, which would force the water down to the point of entrance. By this arrangement a vessel would be kept afloat which would otherwise sink, and it would permit of the stoppage of leaks, and the making of temporary repairs without docking the ship.

All large vessels should be provided with a pair of torpedo boats, to be used during action, which should be lowered and hoisted by steam power; steam power should also be applied to hoisting ashes, and to a steam capstan for working the anchors, and to raising and lowering the tripod masts.

The quarters for the officers and crew of war vessels is a matter of the greatest importance, for men to perform their duties properly should be in perfect health, and a high standard of health cannot be maintained when the officers and crew are crowded into the damp, contracted, ill-ventilated quarters which some of our war vessels present. The system of deflecting armor admits of the most commodious quarters, as all the space between decks in vessels constructed with a high freeboard can be utilized for this purpose, except that occupied by the deflecting turrets. As the accommodations will be entirely above the water line, they will be much dryer than those of vessels where they are partly submerged. The height above the water line will also permit each apartment to have a large port for the admission of light and air; the two most important factors of life and health.

In designing war ships these facts should be recognized;—that vertical armor has been tried, and found wanting; that the cause of its failure to afford protection is its lack of a time element equal to that of the guns used against it; that deflecting armor possesses a time element sufficient to resist the power of guns; that as it is only necessary to absorb a portion of the energy of shot to deflect them, and as we have the same material out of which to make both armor and guns, armor can be made equal in resistance to the power of the guns used against it by giving it an equal time element; that, in order to acquire the great penetrating power needed, guns have to be made of great length, which will require the adoption of the breech loading system; that the day has gone by when victories could be won by ships with their decks crowded with men tugging at the tackle of guns; that in working guns human muscle cannot compete with hydraulic power; that by the aid of hydraulic power one man can more effectively handle a gun, than any number could by the old method; that a

few guns of moderate calibre, capable of piercing vertical armor, with appliances for working them with great rapidity, with their hydraulic gear and gunners efficiently protected by deflecting armor, is a far more effective battery than one of slow working monster guns, firing ponderous projectiles of no greater penetrating power; and that a battery so protected will be more effective than a much larger battery of similar guns unprotected, or not so well protected; that with steel as the material of construction the same strength can be obtained with one half the weight of hull than if wood had been employed; that the stowage capacity of an iron or steel vessel is far greater than that of a wooden one; that the strength of hull necessary for high speed cannot be obtained with wood; that vessels to be used as rams require great transverse strength which cannot be obtained with wood; that the use of wood will not permit of the cellular system of construction; that constructed on the cellular system vessels of iron and steel can be given far more buoyancy and stability than those of wood; that the immense power of modern guns demands the protection of the water line of all vessels with defensive armor, and in like manner the great efficiency of heavy machine guns demands the protection of armor for the men working the battery and greatly curtails the usefulness of unarmored ships.

FIG. 1.

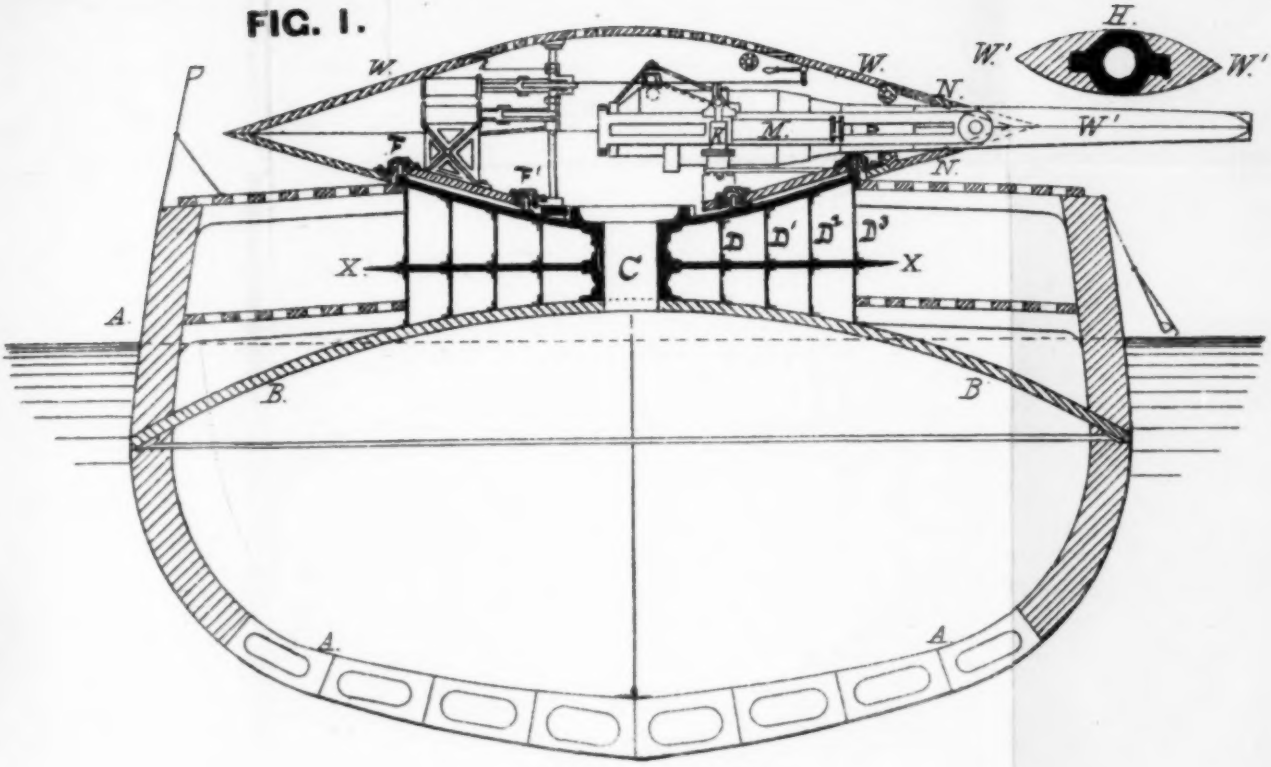
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FIG. 2.

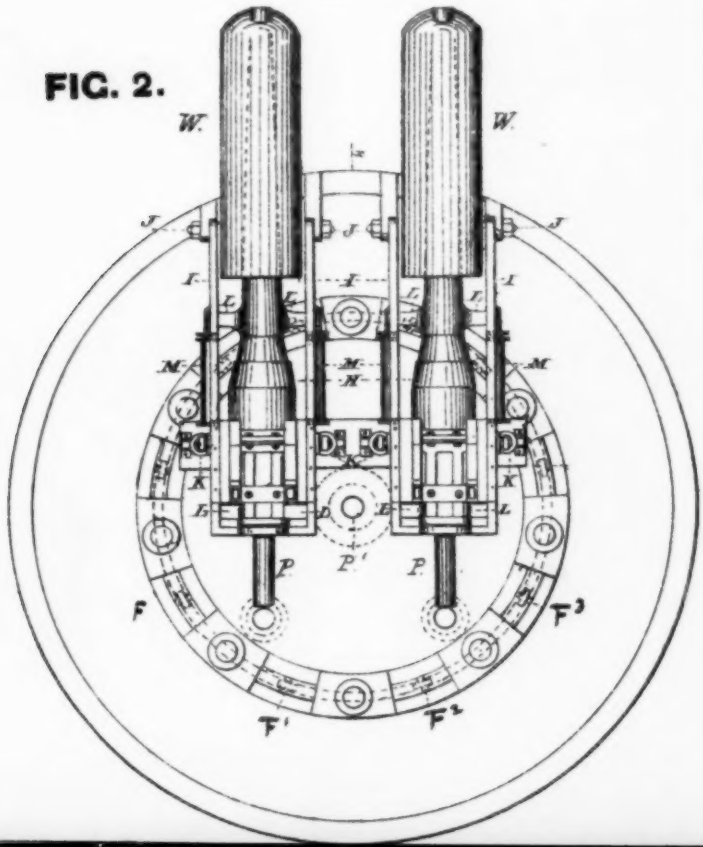
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FIG. 3.

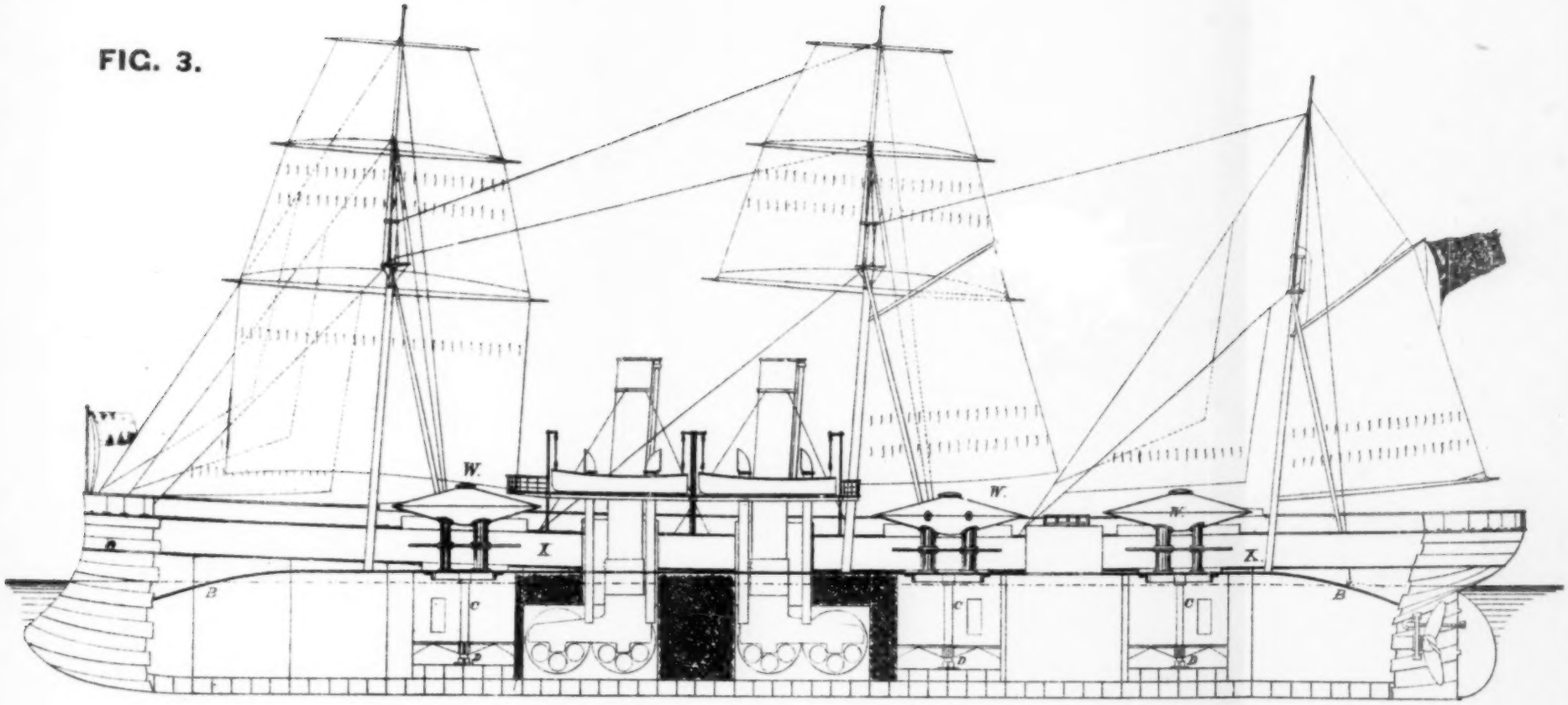


FIG. 4.

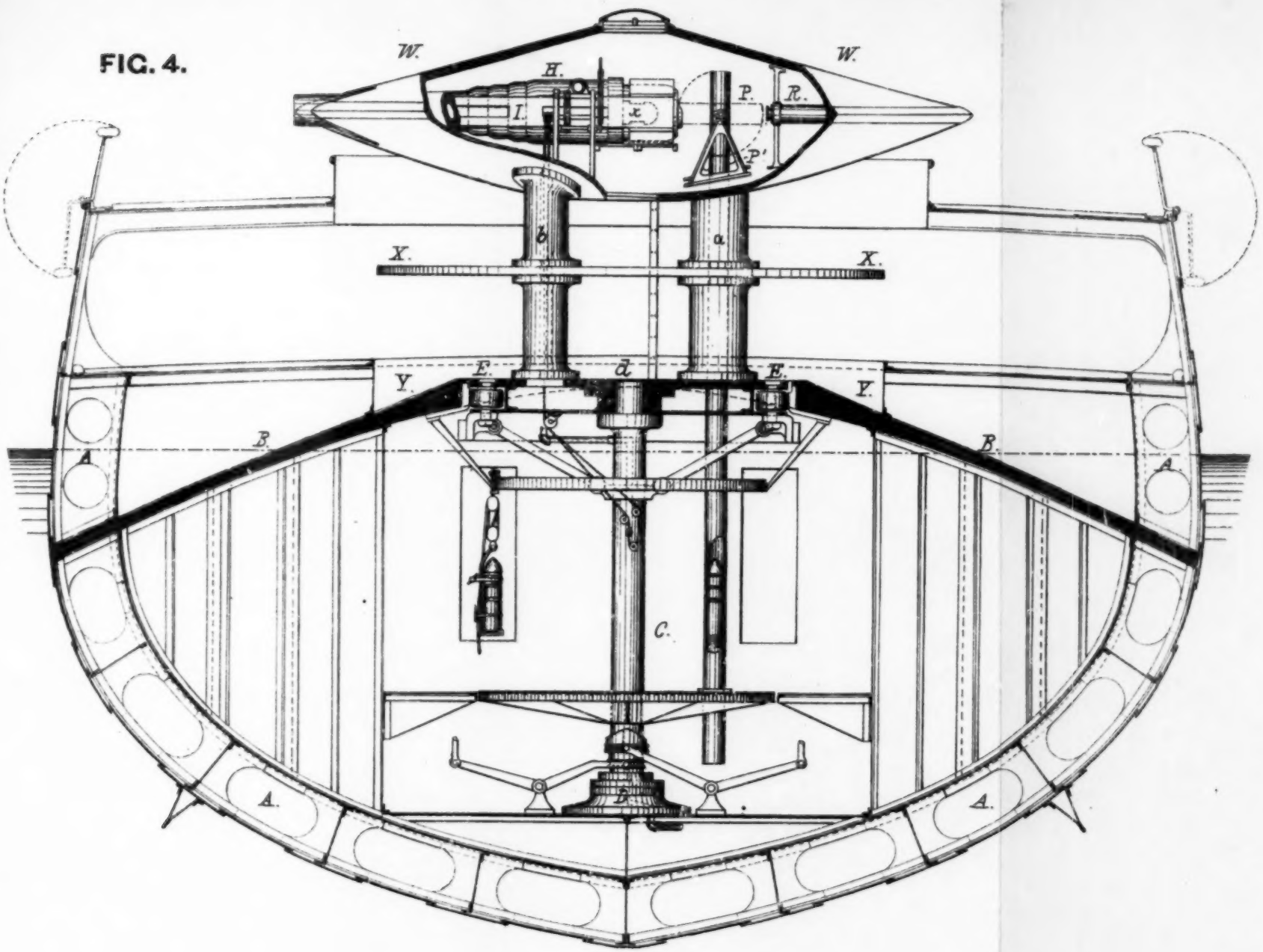


FIG. 5.

FIG. 6.

FIG. 7.

FIG 8.

NAVAL INSTITUTE ANNAPOLIS, MD.,

MARCH 12, 1881.

Lieut. G. W. TYLER, U. S. N., in the chair.

THE RECENT INVESTIGATIONS OF THE GULF STREAM BY THE U. S. COAST AND GEODETIC STEAMER BLAKE.

By Commander JOHN R. BARTLETT, U. S. N.

I consider it a great honor to be connected in any way with the investigation of this great river of the ocean, and it will give me pleasure to lay before the Naval Institute any new facts that I have obtained, under the direction of Mr. Patterson, the present Superintendent of the Coast and Geodetic Survey.

To the United States Coast Survey, first organized by Mr. Hassler, and especially to the systematic examination instituted by Professor Bache, are we indebted for most of our knowledge of the Gulf Stream, a knowledge which has been of inestimable value to the mariner. The investigations begun by Dr. Franklin, and pursued by his descendant Professor Bache, have been continued by Prof. Pierce and Mr. Patterson, but by none with more earnestness than by the present Superintendent, who has the advantage of the more modern and improved instruments. Mr. Patterson kindly gave me permission to use the data obtained by the steamer Blake, in preparing my paper. The Coast Survey deals only in facts, and the superintendent told me that any theories advanced, must be my own. I shall, however, present you the facts and leave you to draw the conclusions.

The facts obtained by the steamer Blake, regard: depths, temperatures from surface to bottom, character of bottom, specimens of water for analysis from surface to bottom, surface and under currents, and animal life from surface to bottom, especially at the latter.

Many of my hearers have probably read more than I on the subject of the Gulf Stream, and some have listened to papers by our

most learned and scientific men in relation to its origin, course, and temperature. A very interesting article appeared in the Galaxy from the pen of Dr. Hayes. Every one has read Lieutenant Maury's entertaining chapter on the Gulf Stream, in his "Physical Geography of the Sea"; but his theory of its source is generally disputed. He says the brine of the ocean is the lye of the earth, and that from it the sea derives dynamical power and its currents their main strength. He traces all ocean currents to differences in specific gravity.

It is its source of which I wish first to speak, in order to lead up to the point at which I hope to be able to give some new data. I will not enter into a lengthened discussion, but I wish to assume that the equatorial current is the source of the Gulf Stream, and I only quote a few words from the best authorities on the subject.

Sir John Herschel says: "The dynamics of the Gulf Stream have of late, in the work of Lieutenant Maury, been made the subject of much (we cannot but think misplaced) wonder, as if there could be any possible ground for doubting that it owes its origin entirely to the trade winds,"

Sir C. Wyville Thompson has some very interesting remarks on the Gulf Stream in his recent work, "The Depths of the Sea," and comes to the conclusion that it is the reflux of the great equatorial current.

Humboldt attributes the origin of this current to the trade winds, and lays the first impulse and origin of the Gulf Stream south of the Cape of Good Hope.

There is no doubt about the equatorial current. Columbus wrote in his journal: "I regard it as proved that the waters of the sea move from east to west as do the heavens." I would liken this great equatorial current to the heart in the human body, supplying the Gulf Stream with fluid as through the arteries, the water finding its way back naturally by the polar and colder currents or veins, to its original source. This action goes on in the Pacific as well as in our own Atlantic. The life or moving power is, as Herschel says, the trade winds, and this force is derived from the sun. Professor Bache, in his paper on the Gulf Stream, says: "The great part which the heat of the sun plays in disturbing the equilibrium of the surface of our globe is well understood. Wherever he shines upon the surface, the air resting upon it is set in motion, so that the circle of the sun's illumination, as it advances over the earth, is a circle of disturbance."

An article in the American Cyclopedia, based on Coast Survey reports and Professor Bache's paper, says: "The equatorial current,

that volume of water moving from east to west on our globe, interrupted by continents, and sending off branches in other directions, again to reunite, may be said to commence, or, more properly, reappear on the west coast of Africa. The action of the trade winds, which blow constantly between the tropics, is the cause of this current, and, without doubt, its velocity is increased by the rotation of the earth on its axis. Flowing on both sides of the equator in longitude 30° W., its breadth is estimated at 300 miles. Here it divides, the southern branch forming the Brazil current, the remainder flowing on to supply the Gulf Stream."

It is said to flow through the Caribbean sea to the Gulf of Mexico. It will be my purpose to show its course from the time we meet it to the eastward of the Windward Islands until it enters the Gulf of Mexico at the Yucatan passage. It is said that, at times, the water flows through this passage from 27 to 50 miles in 24 hours. Near Yucatan, we found it in the month of May flowing at the rate of three miles an hour. From this point the course of the current is generally described as making the tour of the Gulf of Mexico, or following around its boundary, before passing out at the straits of Florida. This is disputed now, with, I think, very good reason. The investigations made by the Coast Survey carry the current passing through the Yucatan passage well to the northward, were the waters are banked up by the pressure, and thus form a head or reservoir for the current, which flows from a point south of the mouth of the Mississippi direct to the straits of Florida.

South of Tortugas, the stream flows to the eastward, gradually increasing its velocity as it moves on. Opposite Havana, where its breadth is about 70 miles, its average rate is said to be two miles an hour in the centre, decreasing on each side; northwest from Elbow Key, where its breadth is about 47 miles, the set, in the centre, is said to be northeast three miles an hour, with an increased rate toward the Florida reefs. The stream now bends to the northward, and, in the straits between Cape Florida and the Bemini Islands, its velocity is said to vary from one-half mile to even five miles an hour. This is the narrowest part of the stream, and I find it stated that its maximum temperature is 85°. The season of the year when it reaches this maximum is not given. I will speak of this part of the stream later on, and will mention the date when giving temperatures or currents observed by the Blake.

In November, 1878, I was ordered to report to the Secretary of the

Treasury for duty on the Coast and Geodetic Survey, and was assigned by Mr. Patterson, the superintendent of that service, to the command of the steamer Blake. My instructions for the first season's work, after the dredging for Mr. Agassiz had been completed, were as follows :

"You will please take soundings in the passages between all the islands from Trinidad to Cuba, not already sufficiently sounded, for the purpose of determining the ridge of least depth of water traversing these passages. Temperatures from surface to a depth of 100 fathoms, and at the bottom, should be obtained as often as opportunities offer, and serial temperatures, from surface to bottom, between the islands and on each side of the shoalest ridge."

It will be seen by these instructions that it was Mr. Patterson's idea to find the amount of water which enters the Caribbean sea between the Windward Islands, and, what was more important than anything else, to observe carefully the temperature of the water at different depths, as these temperatures would give the most interesting data in reference to the circulation.

As Mr. Patterson says in his report: "The discovery by the Challenger of submarine lakes whose temperatures are constant to the greatest depth with that of the ocean at the depth of their rims, rendered it more than ever imperative to determine the depth of the rims separating the waters of the Gulf of Mexico from those of the Caribbean, and its waters from those of the Atlantic, both to the eastward and westward."

As it was very important to connect the fauna of the West Indies with the Arctic fauna, and as naval officers are professionally neither naturalists nor geologists, Mr. Patterson sought the services of Mr. Alexander Agassiz, who consented to take charge of the special work, naming the localities to be dredged over, and taking care of the life obtained. Professor Agassiz joined the Blake with an assistant, and the first part of the season's work, until March 10, 1879, was occupied in dredging and trawling under the lee of the Windward Islands. We met with great success in this very interesting work ; but this part belongs more especially to Professor Agassiz, who will, in due time, present a popular account of the results of his labors. The working of the dredge and trawl was done by the officers and crew under my command.

Besides dredging under the lee of the islands, we made a number of soundings and hauls to the southward of Grenada, enough to develop the channel between that island and Trinidad. The greatest depth was

421 fathoms in a channel 30 miles wide; temperature at bottom, 41½°* We were here the latter part of February, and found the current very strong to the westward. It is stated by a number of authorities, and published as the observation of the English surveyors, that a strong current is felt all along the Spanish Main a few miles from the coast.

In making the passage from St. Vincent to Barbadoes in the first week in March, we experienced a current of about 40 miles in 24 hours setting to the northward, and from inquiry on board English men-of-war and merchant vessels at that time in port, I found they had experienced the same northerly current. I crossed this passage again, in the latter part of March and in the middle of April, finding the same current.

Our method of finding the ridge connecting any two islands was by running traverses, or a line of soundings, begun in deep water and carried at right angles to a line drawn between the islands. The soundings would gradually shoal to a minimum and then increase, when a new line of soundings was run across the ridge at such an angle as to bring the soundings at the shoalest point about four or five miles apart. At every sounding the temperature of the surface was observed, as well as that of the bottom. I have spoken of the passage to the southward of Grenada. Our first sounding and temperature work was between St. Vincent and St. Lucia. A connecting ridge was found between these islands having a greatest depth of 488 fathoms, a bottom temperature of 41½°. The soundings across were 488, 370, 198, 171, 129, 164 fathoms.

It will be seen by the contour lines that the water deepened gradually to the Atlantic and quite abruptly into the Caribbean sea. Traverses were run between all the islands as far as the Virgin islands, with the following depths; Between St. Lucia and Martinique, 548 fathoms, temperature 41°; between Martinique and Dominica, 575 fathoms, temperature 41°; between Dominica and Guadaloupe, 346 fathoms, temperature 44½°; between Guadaloupe, Antigua and Nevis, 386 fathoms, temperature 45°; between Anguilla, Sombrero and Anegada, 1,100 fathoms, temperature 38° on the ridge, but this latter sounding was in a canyon, not more than two miles wide, and on each side of it were only a few hundred fathoms. Between Anegada and Sombrero, we found outside of the ridge, a temperature of 38° at 1,346 fathoms, 37½° at 1,643 fathoms, and 36½° at 2,558 fathoms. The low-

* All temperatures are given in degrees Fahrenheit.

est temperature that was found inside was between St. Thomas and St. Croix, that of 38° in 2,470 fathoms. To the southward of St. Croix, inside of the islands, the temperature of all depths below 800 fathoms was 39° to 39½°, and it was only in the deep hole north of St. Croix that we found anything lower. It will be seen by the contour lines that the deep water was traced in a channel from Anegada passage to a line between St. Thomas and the west end of St. Croix. The temperature at 1,542, 1,517, and 1,508 fathoms, south of Mona passage, was only 39½°, which would seem to indicate a connecting rim from St. Croix to the northward, cutting off the cold water that was found between St. Thomas and St. Croix.

In every passage a series of temperatures, or serial, was taken to the eastward of the ridge, then directly on the ridge, and again in the Caribbean sea The depths for a serial were: surface 2, 10, 25, 50, 75, 100, 150, 200, 300, and so on at each hundred fathoms. The temperature at the bottom for the same depth remained constant in the same locality; by comparison, these agreed with the same depth obtained in a serial. At Barbadoes, St. Lucia, and Martinique the temperatures were at 100 fathoms 56½°; 200 fms., 51°; 300 fms., 45°; 400 fms., 43°; 500 fms., 41½°; 600 fms., 40½°; 700 fms., 40°; 800 fms., 39½°.

Just north of Guadaloupe the temperatures suddenly increased, and at Montserrat were: 100 fms., 67°; 200 fms., 57°; 300 fms., 48°; 400 fms., 45°; 500 fms., 42°; 600 fms., 41°; 700 fms., 40°. There was a slight increase as we neared the Anegada passage. These temperatures remained the same to the Mona and Windward passages, and were carried through the Western Caribbean. The temperatures in the Windward passage in May were: 100 fms., 68°; 200 fms., 61°; 300 fms., 53°; 400 fms., 47°; 500 fms., 43°; 600 fms., 41°; 700 fms., 40°; 800 fms., 39½°. The temperatures between Haiti and Jamaica were not quite as high. In February, the surface was several degrees lower than in May, but the temperatures at 100, 200, and 300 fathoms were the same, at the Windward passage.

Between some of the islands we were five and six days in completing the development of the ridge. The trades blew almost a gale during the months of January, February, and March, hence it was very tedious work, the small vessel of only 320 tons pitching her bows under, while the greatest care had to be exercised by the officer in charge of the sounding to prevent an accident to the wire. We worked during daylight, locating the position of the soundings by bearings taken on points of the islands, at night heading to the wind and sea under just

enough way to keep in our place. While at work among these islands I wrote to Mr. Patterson: "The water does not set into the Caribbean sea through the passages between the islands to any great extent. The trades bank the water against the windward side of the islands, and near their ends the current sets strong to the westward, but we did not find the strong current in mid channel."

In the passages between the Windward islands we saw large quantities of the sea or gulf-weed. In the latter part of April we had calm weather north of Guadaloupe, and I have seen this weed extend for miles in lines always pointing north. This was not owing to the wind, for at the time I speak of it was a dead calm, but seemed to be caused by the current flowing between the islands, which agrees with our observations of the direction of the current. Especially was this the case north of Guadaloupe and near St. Christopher and Saba islands. Again, in the Anegada passage I saw the same string of gulf-weed stretching in lines to the northward. There was a great deal of gulf-weed north of St. Domingo the 1st of May, passing through the Windward passage and south of Cuba; but I saw none south of Jamaica or over the Pedro and Rosalind banks in the same month, nor did I notice the presence of this weed in the latter locality in January, February, March, and April of 1880.

I was very much puzzled over a current experienced on the passage from Kingston, Jamaica, to St. Thomas, in the latter part of December, 1879. The trades were very strong from the eastward, but we had an easterly current of nearly two knots against wind and sea as far as the Mona passage, and a knot to St. Thomas. The captain of an English telegraph steamer whom I met at St. Thomas, who had been three years in the waters in question, stated that he had always found the current setting to the eastward; and I was given the same current by a number of English men-of-war. No dates were given. It is marked on the chart that the current sets to the eastward during the full and change of the moon. North of Guadaloupe, by observation and dead reckoning, we found the current northerly in the latter part of April; after leaving Saba island the current was N. N. W., about a mile per hour: on our way from St. Christopher to St. Thomas we had a current of one mile per hour setting to the eastward in the same month.

The temperature of the surface water from Barbadoes to the Windward passage was from 79° to 80°; in calm weather, in the day-time, it would rise as high as 81°. This was from March, at Barbadoes, to

May, in the Windward passage. In January, 1880, we found the temperature of the surface water in the old Bahama channel and at the Windward passage only 76°. This gradually increased, as we went to the westward and the season advanced, to 78°, 79°, and 80° near the Caymans, in March, and to 81° and even 82°, in May, between the Misteriosa bank and the Yucatan passage. Over the Pedro and Rosalind banks, and north of the Mosquito coast, it was 79° and 79½°, in February and March.

The bottom obtained in the soundings directly on the ridges was generally coral sand and dead coral; on each side, in the deeper water, it was pteropod ooze. As I shall speak so often of this ooze, I may as well describe it now. After reaching a depth of four or five hundred fathoms, we always brought up a light brown or coffee-and-milk colored paste. This paste is formed of innumerable pteropod shells. The pteropod belongs to the division of mollusca, and is characterized by having broad fleshy wing-like appendages or organs of motion. The shell is transparent and very beautiful. This form of life lives at the surface, and when the animal dies the shell sinks to the bottom, and there decomposes and forms the paste or ooze spoken of. In sifting the ooze collected in the trawl, we found a great many whole pteropod shells.

The Mona passage was thoroughly sounded, and the greatest depth was found to be only 260 fathoms; the islands of St. Domingo and Porto Rico being connected by a plateau of like character with Porto Rico.

It will be seen by the soundings from Grenada northward, that the connecting ridges have the same character of mountain and valley as the lands which they connect. Between Martinique and Guadaloupe, we found a peak in mid channel with only 40 fathoms, deepening on all sides to several hundred.

The bottom in the Mona passage was very hard, and no specimens were obtained. The surface of the connecting ridge seemed swept of everything. The wind was very strong while we were at work here, and the current west of Porto Rico set to the southward near the island, but at the west side of the passage the current set to the northward; this was in May. From the Mona Passage soundings were taken every 20 miles, on the way to the Windward passage, north of St. Domingo. The depth averages over 2,000 fathoms with a bottom temperature of 36½° to 37°. There was a light easterly breeze here, and we found the current to the westward at the rate of 1½ knots per hour.

A very good profile was made of the ridge connecting Cuba with Haiti the first season, and this was verified and many new soundings were added last winter. The deepest water on the ridge was less than 800 fathoms. The temperature at 700 fathoms was 40°; below 700 fathoms, 39½°; and the same temperature was always found at all depths below 700 fathoms in the Western Caribbean by the Blake while under my command, and by Lieutenant-Commander Sigsbee in the same vessel in the Gulf of Mexico. The temperatures outside of the ridge at this passage were: 800 fathoms, 39°; 1,000 fathoms, 38½°; 1,200 fathoms, 38°; 1,500 fathoms, 37½°; 2,000 fathoms, 37°. Inside of the ridge the temperature was constant at 39½° from 750 fathoms to 1,900 fathoms, 10 miles inside the ridge, and to 3,000 fathoms farther on. The first season we were not able to get any specimens on the ridge at the Windward passage with the sounding cylinder, except a few small stones. The moment we crossed the immediate ridge on either side, the bottom was pteropod ooze. Last winter I made two hauls of the dredge in 700 fathoms directly on the ridge. The dredge brought up a quantity of hard coral rock or crust torn from the bottom. It had very much the appearance of old mortar, and was similar to the coral rock found on the northwestern end of Haiti, this part of the island being of coral to the very tops of the mountains. The southwestern end of the island is of volcanic formation, and is covered with luxuriant foliage, but at St. Nicholas Mole it is barren. The land, as seen from the sea, lies in terraces. Barbadoes is of similar formation in terraces to 300 feet above the sea, and all coral.

The second haul of the dredge was near Cape Maysi, still in 700 fathoms. The same bottom was found, also hundreds of shells of the "Scalpellum regium" (a kind of barnacle), which is described by Sir C. Wyville Thomson in his "Voyage of the Challenger." These shells were black and looked very old.

A few very small sponges and sea-urchins were brought up, but everything that could be swept away by a current was wanting. As I remarked before, all the ooze brought up, when sifted in water, was found to contain many whole pteropod shells, but my attention was particularly drawn to the fact that south of the ridge the ooze contained many more whole shells than that obtained to the northward. The current must have swept them off the ridge. While sounding between Miraporos island and Cay Verde, in 1,400 fathoms, the sounding cylinder came up literally packed with these shells. The current in which they were suspended is here retarded by the Bahama banks, and they fall

in this eddy; of course they must be falling everywhere, but here they seemed in excess of any other place. The old Bahama channel was thoroughly sounded by the Blake, the least depth being abreast of Paradon light, 284 fathoms; 500 fathoms abreast Lobos Cay light (this depth was taken over a sounding marked on the chart 900 fathoms, no bottom). A great many soundings were taken between Jamaica and the south-west end of Haiti, the result being the development of a narrow channel connecting the waters of the main Caribbean with the waters north of Jamaica. This channel runs close to Haiti, with a greatest depth of 1,200 fathoms, the bottom temperature 39½°, and a general depth of 1,000 fathoms. The bottom everywhere was ooze. South of Navassa we found a large bed of the pteropod shells. The course of this channel is northerly along the western end of Haiti, where it does not exceed a width of five or six miles, thence westerly south of Navassa island, with a tongue to the northward and another to the westward between Formigas bank and Jamaica. We were here in the latter part of January, spending some ten days. We always found the current setting to the eastward, from one-half to one knot per hour. We met the English squadron at Port Royal, and I examined the logs of various vessels; all had found the same current setting to the eastward as far as the Mona passage. Jamaica was connected by soundings and several temperatures with the Mosquito coast *via* the Pedro and Rosalind bank. The depths between Jamaica and the Pedro bank were: from Jamaica, 322, 320, 293, 236, 381 and 447 fathoms, the temperature of the latter sounding being 44½°. My map was too small to draw the 500 fathoms curve, but the water to a depth of 600 fathoms makes in well to the westward, south of Jamaica. We spent eight days under the lee of N. E. Cay waiting for a lull in the trades to do the next channel; but it did not come, and we returned to Kingston, remaining there two weeks. Two lines only were run between the Pedro and Rosalind banks. The depths across were: 440, 675, 733, 642, 688, 609, 561, 478, 435 and 264 fathoms. The lowest bottom temperature was at 733 fathoms, 40°, the others all above 40°. I think it very probable that there is less water to the eastward of where we ran our lines. There was a little more than 200 fathoms in the narrow passage west of the Rosalind bank.

The bottom in the channels was very fine coral sand, not the smooth bottom found where there was a strong current. The current during February, March, and April did not seem to be setting to the westward through these channels, except in the very narrow one west of the Ros-

alind bank. Several captains of vessels reported a northerly current to the eastward of these banks. To the eastward of Portland Rock, the eastern extreme of the Pedro bank, we found a very strong easterly current in the latter part of February, the trades blowing a gale at the time. A line of soundings was run from Santiago de Cuba to the east end of Jamaica, and a depth of 3,000 fathoms was found 25 miles south of Cuba. Subsequent soundings proved this spot to be the eastern end of an immense deep valley extending from between Cuba and Jamaica to the westward, south of the Cayman Islands as far as the Bay of Honduras.

The Cayman Islands and the Misteriosa bank were found to be a submarine extension (very steep on its southern slope) of the range running along the southeastern side of Cuba. The valley is narrow at its eastern end, but widens between the western end of Jamaica and Cape Cruz, where the soundings were 3,000 fathoms within 15 miles of Cuba, and 2,800 fathoms within 25 miles of Jamaica. This valley is 700 miles long, with an average breadth of 80 miles. It covers an area of over 85,000 square miles, having a depth nowhere less than 2,000 fathoms, except at two or three points which are the summits of submarine mountains, and with the greatest depth of 3,428 fathoms. The low island of Grand Cayman, which stands scarcely 20 feet out of the sea, is really the summit of a mountain 20.568 feet above the bottom of this submarine valley, an altitude exceeding that of any mountain on the North American continent. Between Misteriosa bank and Chinchorro bank the soundings were regular at 2,500 fathoms. North of Misteriosa and Grand Cayman to the Isle of Pines and Cape St. Antonio, the soundings were generally 2,500 fathoms. The bottom everywhere in the western Caribbean is pteropod ooze, with a slight mixture of coral sand, which has been brought up by the wind and water from the islands and keys.

A wide band of westerly current was found south of the Caymans and the Misteriosa bank, turning to the northward at Chinchorro bank, and so following the coast to the Yucatan passage. There was a narrow stream joining this main current from a passage between the Rosalind bank and the Musquito coast, but I did not detect any flow from the other passages. North of the Caymans we found very little, if any, current. There is said to be a current which sets strongly to the eastward south of Cape St. Antonio.

Thus I have given you a summary of the data obtained by the Blake in as brief a form as possible.

The development of the ridges connecting the islands and the deep valley in the western Caribbean sea are certainly very interesting, considered as physical features, and I think that the temperatures obtained at different depths, especially on the ridge at the Windward passage, together with the currents observed, give us facts enough to lay out a possible course for the equatorial current from a point southeast of Barbadoes to the Yucatan passage. There is, certainly, a very large volume of water pouring through the Windward passage, flowing south of Cuba and so on to the Gulf of Mexico; and the temperatures of the water at different depths agree at the same season with those found in the Gulf of Mexico and the course of the Gulf Stream as I have laid it out.

Where does it get this temperature? It is not warmed in the Gulf of Mexico, for the latest theory is that it does *not* flow around this basin. Professor Hilgard, of the Coast Survey, has given a lecture quite recently before the Academy of Science, entitled "The Basin of the Gulf Stream", in which he shows that the current merely enters the passage at Yucatan to be forced by the head of water to the northward and westward out through the Florida straits. The currents in the Gulf are not connected with the Gulf Stream, and are very slow. The temperature is several degrees higher at the same depth at the Windward passage than at the Barbadoes and from Trinidad to Guadaloupe. The comparison of these temperatures is made from observations taken at both places in the months of January and February. The temperature below 800 fathoms in the western Caribbean and Gulf of Mexico could only enter over the rim at the Windward passage and between Haiti and Jamaica; but at the latter point there is no current setting that way; in fact, the pteropod shells showed an eddy.

I suggest that the water of the Gulf Stream is warmed in the main Caribbean, and that there is a possible current flowing around the entire boundary. The equatorial current striking against South America is deflected north, and when it reaches the island of Tobago all that can flow between this island and the main land and south of Grenada does so. This current is said to be felt along the Spanish Main. The greater part of the equatorial current, however, is deflected north between Barbadoes and the Grenadines, finding its way to the westward whenever it meets a passage. Passing through, it would naturally be driven towards the Spanish Main by the trade winds, and thus bank up in the southwestern corner. While working between

the islands south of Guadaloupe, we were always well to windward during the night and therefore felt the northerly set which I wrote of to Mr. Patterson, but north of Guadaloupe, in April, we had comparatively calm weather, and here the current came from the westward, and above Saba island was flowing as if to follow around the Virgin islands. After turning these, it would be helped along towards the Windward passage by the northeast trades.

As stated, the temperature to 400 fathoms suddenly increased, as we passed north of Guadaloupe. Could not this be accounted for by the equatorial current having made the circuit of the main Caribbean and been warmed on its passage over shoals and banks, after traveling nearly 3,000 miles? The current said to flow along the Spanish Main would be deflected north by the Isthmus and keep on following inside, or to the eastward of the banks connecting Jamaica with the main land, and so south of St. Domingo, to pass out through the Mona passage and the Anegada passage, to flow along north of Porto Rico and St. Domingo to the Windward passage. We found a current in the latter part of April flowing north through the Mona passage and joining the current to the westward. Of course we must have many more facts to substantiate any such theory as I have given. The temperature of the water at different depths must be observed to the eastward of the Anegada passage and over the main Caribbean; and these temperatures must be taken in the same season at the different localities. I will not occupy your attention any longer here, but you can deduce your own theories from the facts given. The contour lines drawn on the map, with the exception of those along the coast of South America, are from the soundings of the Blake. The 100 fathoms curve, is from the United States and English surveys.

Last summer during several weeks the Blake was employed entirely on a dredging cruise, extending from a point off Charleston, S. C., to the Georges banks. Professor Agassiz accompanied the vessel, and named localities for dredging and cared for the life obtained. We had dredged off Charleston in 100 fathoms, then in 200 fathoms. Mr. Agassiz wanted 400 fathoms for the next haul. We steamed to the eastward, but instead of finding deeper water it shoaled. The soundings across the stream were as follows: 142, 198, 225, 217, 236, 229, 258, 334, 382. 364, 337 fathoms.

The next point for dredging was off Cape Hatteras. To reach this point, I kept in the imaginary axis of the stream as marked on the chart, and sounded every five miles, with the following depths: 257, 291, 274, 288, 265, 262, 257, 247, 233, 246, 267, 288, 310, 338, 362,

400. 457, 892, 1,386, the above from lat. 32° 00′ N. to lat. 33° 30′ N.

These soundings were announced in the newspapers as the discovery of a plateau extending from the Carolinas to the Bahamas. This plateau was known at the Coast Survey office. Professor Bache spoke of it as long ago as 1856. He stated: "The discovery has been made that soundings can be carried nearly across the Charleston section of the Gulf Stream, and that after losing them on this section for a short distance, they were reached beyond the axis of the stream, as resulting from the observations of Lieutenants Maffit and Craven, U. S. N., Assistants in the Coast Survey." He says: "The bottom of the sea slopes gradually in this section for some 50 miles, reaching a depth of about 20 fathoms; then more rapidly to above 65 miles and the depth of 100 fathoms, and suddenly falling off to a depth greater than 600 fathoms; at about 100 miles from the shore, where the depth is 300 fathoms, a ridge with a very deep slope on the inshore side, and a little less to seaward, occuring 1,500 feet above the hollow to seaward of it, and distant about 12 miles from it. A second rise of 500 feet, on a base of 12 miles, followed by a depression of 300 feet on a base of 15 miles, and then by a gentle slope upwards. It is altogether probable that all the depths found by observation are greater than the actual ones, but the bottom was brought up in several cases, showing that the lead had reached it. It is most probable that the proportions are not far from correct."

It will be seen how difficult it was to obtain the depth with the old methods. The soundings over this section were reduced one half by the Blake, and at this rate the temperatures taken can hardly be relied upon. We were a little more than two minutes taking these soundings, and always brought up a specimen of the bottom. The temperatures that I find in the diagram of Prof. Bache are not as low as those of the Blake, although we had less water. The season was the same—in July. The temperature of 57° was found at 350 fathoms, and also at 600 fathoms, by Craven and Maffit. The thermometer probably never reached the bottom. We found a temperature of 45° to 46° from 300 to 380 fathoms. The bottom off Charleston was coarse grey sand, black specks, broken shells to 100 fathoms; then fine green sand and black specks, then came coral sand, broken shells, and pteropod shells. As we came more into the stream, the bottom was washed bare, but the cylinder brought up small pieces of coral rock and coral sand. Mr. Agassiz has reported on the life obtained.

As we came north along the Gulf Stream and the water deepened, globerigina ooze began to appear in the bottom specimens. The investi-

gation of the Gulf Stream off Florida and as far as Hatteras, will be renewed by the Blake in the spring. The temperature of the water off the Georges bank in 300 fathoms was 40°. Other soundings and temperatures that we took last summer are interesting, but I must close my remarks, as I wish to speak of the methods of obtaining the results given you this evening. Some of my hearers have probably seen Lt.-Comdr. Sigsbee's very interesting and instructive book, issued by the Coast Survey, on deep sea soundings. I wish all interested in this subject could read it. Lt.-Comdr. Sigsbee was in command of the Blake for four years, and sounded the whole of the Gulf of Mexico, making the necessary examination into its physical conditions. Most of our apparatus was either invented by this officer, or are improvements on known methods.

The Blake is a small steamer of 350 tons, belonging to the Coast Survey. She is manned by eight officers and 38 men, and is fitted expressly for deep sea sounding and dredging. It has been my good fortune to have associated with me on this duty, officers who have rivaled me in their interest in the work. The great work done by the Blake bears testimony to their earnestness, and the records to their care and precision.

THE CHAIRMAN: I have listened with much interest to the paper which has just been read, and I am sure that all will join me in extending thanks to Comr. Bartlett for giving us the results of his labors in this very interesting form.

Those of us who have had occasion to sail along the south coast of San Domingo have noticed the easterly set which has been mentioned by the lecturer. His explanation of it is naturally suggested by the form and position of the shoals in the western Caribbean, and is probably the true one.

While it is doubtless true that the bulk of the equatorial current sweeps north through the Yucatan Passage, I do not think that Comr. Bartlett means to assert that the whole of it does so. I think it is equally unquestionable that part of the current is deflected across the Campeche Bank, and thence along the coast of Mexico. Of course, the force of this current varies with the wind and season, but I do not think 1½ to 2 knots at all unusual, particularly across the Banks.

I am glad to know that it is the intention of Comr. Bartlett to furnish the Institute with another paper, to embody the results of the next season's work. I think we may anticipate from the coming investigations, discoveries that will be even more valuable and interesting than those which we have had the pleasure of hearing about this evening.

95°
90°
85°
80°
30°
25°
20°
15°
10°
G U L F
O F
M E X I C O
SIGSBEE DEEP
FLORIDA
YUCATAN PASSAGE
ISLAND of CUBA
YUCATAN
GRAND CAYMAN
MISTERIOSA
BARTLETT DEEP
JAMAICA
ROSALIND
PEDRO BANK
HONDURAS
MOSQUITO COAST
PACIFIC OCEAN

85°
80°
75°
FLORIDA
YUCATAN PASSAGE
ISLAND OF CUBA
WINDWARD PASSAGE
GRAND CAYMAN
MISTERIOSA
BARTLETT DEEP
JAMAICA
ROSALIND
PEDRO BANK
HONDURAS
MOSQUITO COAST
85°
80°
75°

CHART OF THE

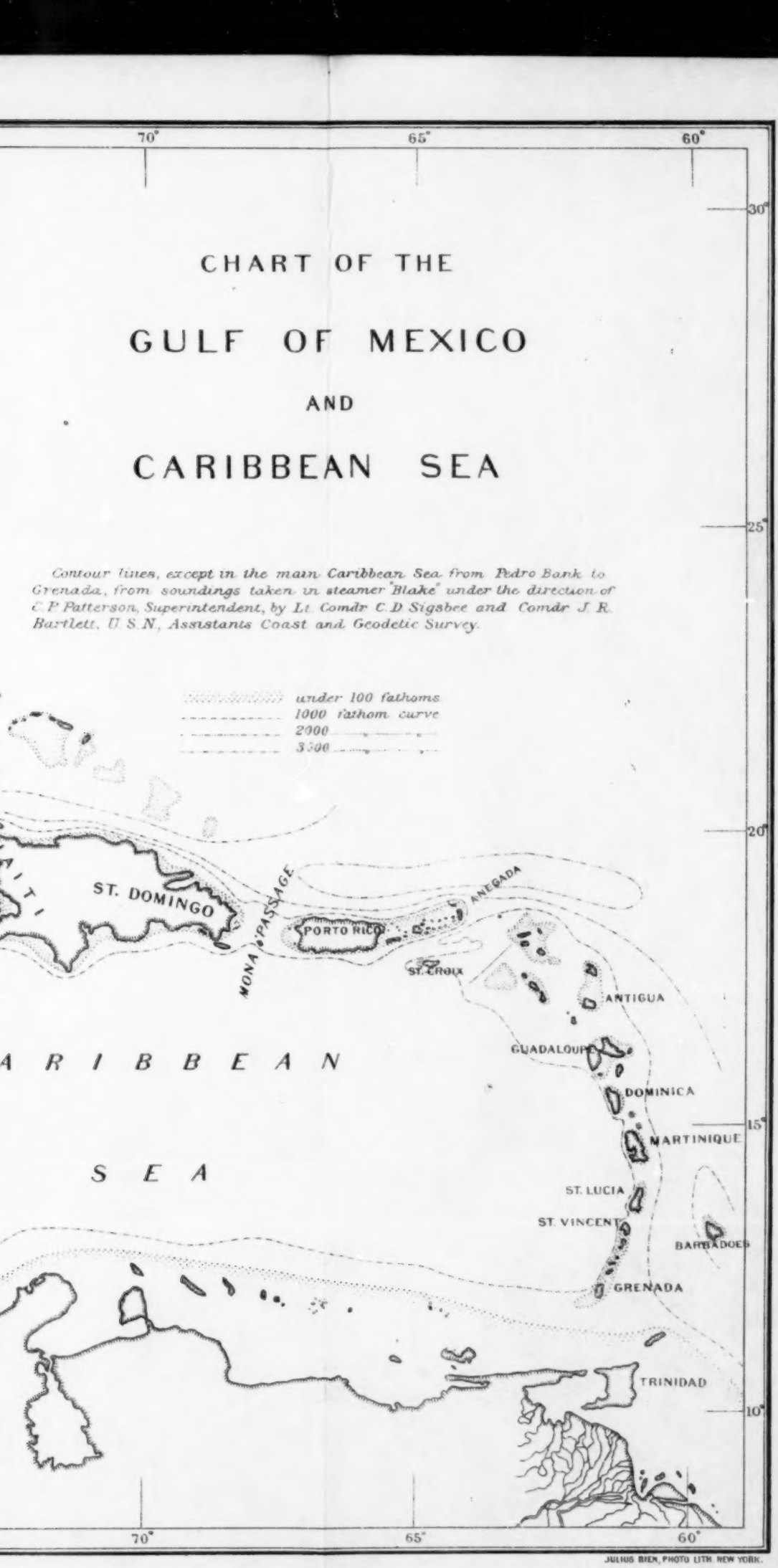
GULF OF MEXICO

AND

CARIBBEAN SEA

Contour lines, except in the main Caribbean Sea from Pedro Bank to Grenada, from soundings taken in steamer "Blake" under the direction of C. P. Patterson, Superintendent, by Lt. Comdr C. D. Sigsbee and Comdr J. R. Bartlett, U. S. N, Assistants Coast and Geodetic Survey.

under 100 fathoms
1000 fathom curve
2000
3500



JULIUS BIEN, PHOTO LITH. NEW YORK.

PRIZE ESSAY.

1881.

BUREAU OF ORDNANCE, NAVY DEPARTMENT,

WASHINGTON, MARCH 8, 1881

Lieut. CHARLES BELKNAP, U. S. N.,
Secretary U. S. Naval Institute.

SIR:—

We have carefully perused the four essays sent in competition for the annual prize offered by the U. S. Naval Institute, for 1881, and we consider that the essay bearing the motto, "*Aut Cæsar, aut nullus*" should be classed first in order of merit.

Very respectfully,
WILLIAM N. JEFFERS, Commodore, U. S. N.
JOHN LENTHALL, Chief Constructor, U. S. N.

NAVY YARD, BOSTON, FEBRUARY 7, 1881.

DEAR SIR:—

In compliance with the request of the Executive Committee of the Naval Institute, conveyed in your letter of Nov. 15, 1880, I have examined the essays, four in number, received in competition for the prize of 1881, and have to report my opinion of their merit in order as follows:—

1st. "*In via virtute, via nulla.*"
2nd. "*Fors clavigera.*"
3d. "*Aut Cæsar, aut nullus.*"
4th. "*Pro patria.*"

I beg to add that neither of the essays embraces a complete plan with proper drawings, dimensions and descriptions of "The Type of (I) Armored Vessel, (II) Cruiser Best Suited to the Present Needs of the United States", with reasons assigned why the types should be adopted. In fact, the largest share of each of the essays is taken up with matter foreign to the subject of the prize essay.

Yours truly,
J. W. KING, Chief Engineer, U. S. N.

Lieut. C. Belknap,
Secretary Naval Institute,
Annapolis, Maryland.

THE TYPE OF (I) ARMORED VESSEL, (II) CRUISER, BEST SUITED TO THE PRESENT NEEDS OF THE UNITED STATES.

By Lieut. E. W. Very, U. S. N.

"*Aut Cæsar, aut nullus.*"

In the treatment of the subject proposed for competition, there are two radically different courses that may be pursued. By the first, which may not inaptly be termed the method of induction, a type of vessel may be selected which shall show the development of some one or more excellencies to an extreme; and, having fully worked out all the details of its constructional points, it becomes an easy matter to cite individual instances involving different combinations of attack and defence that shall prove this type to be the one best suited to the needs of the country. This is the method that is most generally adopted either by those who give but a casual attention to the subject or by those who, having at some time past become especially attracted by certain elements of naval strength, have from force of constant thinking and argument come to treat them as hobbies to be applied everywhere and under all circumstances. It is from following this method that we find devotees of an exclusive type of ram, torpedo vessel, gun boat, or heavy armored defence vessel.

The second method, or the one of deduction, is the one which the writer proposes to follow. It is proposed in what follows, 1st, to determine what the necessities are calling for the use of a navy, 2nd, to determine the importance of, and amount of variation in, the services required of vessels in the fulfilment of the demands of these necessities, 3rd, to determine what types amongst those represented in different navies may be safely excluded from consideration on account of the lack of probability of an urgent necessity arising for their use, 4th, to select from the remaining types the ones best calculated to deal with the necessities which will either certainly or most probably arise, 5th, to describe in detail the modifications which these most probable necessities demand. It is considered that this is the true

method of determining the types of vessels best suited to the needs of the country.

The types of naval vessels best suited to the needs of any maritime nation are those which are best adapted to fulfil the services that such vessels will be called upon to perform; the character of the services, depending upon the circumstances most liable to occur giving rise to necessities for a navy.

Before, therefore, any just rules can be laid down for guidance in the establishment of architectural types, a thorough examination must first be made into the different conditions of international intercourse giving rise to necessities for a navy. The circumstances governing the occurrence of these necessities being known, it is then necessary to examine into the probabilities of their occurrence in the case of the particular nation under consideration as determined by the geographical and political situations of the country; for upon these probabilities depend the importance of, and the amount of variation in, the character of the services required; the former quality determining the power of the standing navy both as a whole and as regards individual vessels, and the latter determining the limitations in type.

The circumstances which may occur giving rise to necessities for a navy are common to all maritime nations from the nature of commercial intercourse and international responsibilities, and it is by no means rare to find the possibility of the occurrence of one or more of them, in some especial contingency, quoted as a sufficient reason for the development of a particular type of vessels. If this be a true method of determination then obviously all the possible necessities must be provided for. An examination of all the necessities will show however that the existence of some calls for a force of superior strength to that of another nation, and since the necessities are common to all, this method leads to a striving after the impossible.

The truth of this argument is clearly demonstrated in considering the development of the French iron-clad fleet under the second empire with the result obtained. This fleet was developed with the sole view of attaining a superiority of sea-going strength over Great Britain, and consequently over every other nation; as is made manifest by the discussions of the French naval budgets of 1855—70. The probability of the occurrence of a war with Prussia was, for several years, much greater than that of a war with Great Britain, and when it came, the powerful French iron-clad fleet proved utterly unfit for the main necessity that arose for its use, namely, the blockade of Prussian sea-

ports. The great draught of the iron-clads and the expense of keeping them in their stations made them useless for the purpose. It is therefore the certainty or the great probability of the occurrence of one or more of these necessities that must truly determine the proper type of development.

Nations are guided in their intercourse with each other in accordance with the conditions imposed by a state of war or peace. According to the existence of these conditions any single nation is with respect to another, a belligerent, an ally, a neutral, or in a state of perfect amity; each condition giving rise to duties and necessities peculiar to itself.

The necessities which may arise in any maritime country for a navy, growing out of a condition of a belligerent may be classified as follows: 1st, the defence of seaports and the mouths of rivers and bays; 2nd, the prevention of a blockade of these ports and rivers, or the breaking up of a blockade already established; 3rd, the protection of national commerce; 4th, the breaking up of the enemy's commerce; 5th, the crippling of the enemy's naval force; 6th, the blockading of an enemy's ports; 7th, the transportation and convoy of land forces and the assistance of armies landed in an enemy's country.

From an examination of these necessities, with the view of ascertaining the probability of their occurrence in the case of a war in which the United States is concerned, it is found that the services of naval vessels in protecting national commerce will inevitably be required, for the following reasons. An attack on the commerce of a nation is one of the most effective measures to be employed in war, since it inflicts a great injury by the use of a small force. The magnitude of the injury does not depend simply on the amount of commerce actually captured or sunk, but upon the total value of that branch of industry and the power of the government to give it efficient protection. Since the United States possesses a commerce of constantly increasing importance, and since its nature deprives it of the property of self-protection, a navy becomes necessary. That this need will arise in the case of a war with a nation possessed of a navy is certain, but to be inevitable it must apply to all cases. The condition of United States commerce at the close of the civil war demonstrates what can be done by a belligerent without a navy. Its ruin was complete although at the outset the enemy possessed no sea-going navy, and throughout the war his seaports were closely blockaded; indeed the injury was mainly due

to the devastations of a vessel that, during her entire life time of four years, never entered a southern port. From this example it may be safely inferred that under any circumstances of war United States commerce will be attacked and therefore will need a defence.

The necessity for crippling the enemy's naval force is co-existent with the necessity for protecting commerce and this reason alone is sufficient to establish the certainty of its occurrence. The necessity for breaking up an enemy's commerce may, in the case of the United States, be considered a certainty, for the following reasons. In a war with Great Britain or France possessing powerful fleets that may act offensively on our coasts from bases not far distant, attacks on this very important commerce become a necessity, not only to deprive them of a source of income and channel of supply, but, what is of more vital importance, to divert fleets from offensive to defensive operations. In case of war with nearly every other nation the distance of the countries from each other precluding land operations renders attacks on commerce the main method of carrying on a war.

There are two classes of necessities that may arise calling for a naval defence of seaports and bays: 1st, those resulting from regular attacks by a strong force of the enemy, having for an object the destruction of the land and water defences, the capture of a seaport, or the establishment of a landing point for troops; 2nd, those arising from the dashes of single cruisers into weakly defended ports for the object of destroying commerce and supply depots or for obtaining fresh supplies of provisions and fuel. The great distance of United States coast ports from an enemy's base of action renders the probability of the occurrence of the first class of but slight magnitude except in so far as a war with England, France or Spain is concerned. But this same reason, together with the immense extent and vulnerability of the coast, renders the liability very great with regard to the occurrence of the second. Rapid cruisers, engaged in assaults on United States commerce, and hampered by the laws of neutrality from getting supplies in foreign ports near the United States, will undoubtedly run great risks in making dashes into weakly defended ports in order to renew supplies. That such actions will take place in a war with any nation cannot be established as certain, but the fact that they are of common occurrence in maritime warfare renders the general probability of sufficient magnitude to call for serious attention.

The probability of a blockade of United States ports by an enemy cannot be considered great except in the case of war with Great Brit-

ain or France, for the reason that a blockade, being the most difficult and expensive of all maritime operations in any case, is, in the case of the United States, lacking in the most essential feature necessary to success; the vicinity of a base of operations. The difficulty of maintaining a blockade of even nominal value in the absence of a base of operations in the vicinity is fully evidenced by the results of the blockade of the mouth of the Elbe by the French in the late German war. In spite of the strong iron-clad fleet kept cruising in those waters, the regular trips of German mail-steamers were never stopped, and although German iron-clads did not get to sea, the rigidity of the blockade cannot be claimed to have been the cause of detention. A blockade of one or two United States ports would not inflict an injury commensurate with the expense of maintenance. To be effective, all the great ports from Portland to Baltimore must be thoroughly sealed, necessitating an immense fleet operating over a great expanse, and even then leaving free the whole southern coast.

The probability of a blockade of an enemy's ports cannot be considered of even ordinary magnitude except in the cases of the colonial ports in the vicinity of the United States and in these cases the probability is entirely dependent on the circumstances. For example; a blockade of Cuba would be probable, as it could be accomplished without difficulty and would inflict a great injury on Spain. A blockade of Bermuda is improbable, since its maintenance would be doubtful and the expense would be greater than the injury inflicted. The only operation that could be carried on against that island would be the one of actual capture.

The necessity for the transportation and convoy of land forces is, with regard to the United States of the least of all probabilities, for the reason that except in so far as Mexico is concerned, and perhaps the Central American nations, and the colonial possessions in the vicinity of the country, land operations would not be undertaken. With Mexico the probability would be slight owing to the more advantageous method of land advance.

The duties and necessities arising from the condition of an ally are comprehended in those of a belligerent and being of a similar nature require no especial examination. In the condition of a neutral a nation is bound to maintain a position of amity towards all nations that are at war and with whom the government is in friendly relations. This duty requires that no aid shall be given to one of the belligerents beyond the requirements of common humanity that shall be prejudicial

to the warlike status of the other. The necessities which may arise in any maritime neutral nation, calling for the services of a navy may be classified as follows: 1st, to prevent its citizens from supplying a belligerent with articles that are recognised as contraband of war; 2nd, to prevent the giving of aid and shelter to a belligerent beyond the requirements of common humanity; 3d, to prevent the carrying on of warlike operations by a belligerent within the neutral territory; 4th, to protect national life and property in belligerent territory from danger during warlike operations; 5th, to prevent an unjust interference by a belligerent with the rights of neutral commerce.

Examining these circumstances, as has been done in the case of war, it is found that a very strong probability exists of the occurrence of the first named necessity. The United States furnishes the greatest market in the world for small-arms and small-arm ammunition, and since war itself is the main cause for a demand for such articles it is not to be expected that manufacturers will of their own volition respect the obligations of neutrality in the prosecution of their business. There is therefore almost an absolute certainty that in case of any war, United States citizens will attempt to violate neutrality by furnishing one if not both of the belligerents with munitions of war. The same circumstances will exist and in but a slightly less degree with regard to attempts to furnish fast cruisers or commence destroying vessels. It may be claimed that all such attempts will be frustrated by the use of proper preventive measures of a land-police character, not requiring the use of naval vessels. The escape of a single cargo of arms or a single armed vessel from national territory constitutes however a sufficient breach of neutrality, provided all possible attempts have not been made by the government to prevent it. If it can be established that the timely use of a naval vessel would have prevented the escape, the United States could not plead the non possession of a navy as an excuse for the breach. The government is able to support a navy and, being able, it is its bounden duty to have one if circumstances exist where the services of naval vessels may protect its neutral position.

With regard to the second circumstance, the probability exists but it is of slight magnitude. A vessel of a belligerent may seek a United States seaport for the purpose of renewing her fuel or supplies, and it is not to be expected that citizens will withold these articles when fair and probably high remuneration is offered. In any case the vessel is a power in herself, and an exhibition of corresponding power may be

necessary to enforce a command to either leave or remain in a port when ordered to. The third circumstance although far from being a certainty is of a much greater probability than the second. Belligerents in pursuit of each other's commerce would probably send their cruisers to the vicinity of United States coasts, if such commerce frequents it. In such cases the temptation is irresistible to trespass upon neutral territory in chasing merchant vessels or, when cruisers are at anchor in or sailing through neutral waters, to send expeditions of warlike character to operate either within or without those waters. Such actions must be prevented at all hazards and they can only be prevented by the use of naval vessels.

The fourth circumstance must be considered as inevitable. United States citizens in the pursuit of trade or pleasure are found at all times in all countries; and, wherever warlike operations are carried on by other than barbarous nations, there will certainly be found citizens who through necessity or carelessness are in danger of losing either life or property. The Government owes a protection to its citizens and such protection can only be surely given by placing them upon inviolable United States territory. In by far the majority of cases such protection is only to be found on vessels of war. The fifth circumstance is of remote probability, but its occurrence brings about a condition of imperfect neutrality. The dangers to which occurrences giving rise to an interference are exposed renders a navy, as a preventive power by an exhibition of force present at the seat of war, a constant necessity.

In a condition of perfect amity, a nation is bound to make every exertion to preserve the amicable relations existing and to strive to ensure a peaceful adjustment of all differences that may arise with other Powers. The circumstances that give rise to necessities for a navy in time of peace may be classified as follows: 1st, To prevent citizens of the country or foreigners within the national territory from violating the laws of amity by actively sustaining foreign insurrection or rebellions, or from making arbitrary acts of reprisal for injuries done by citizens of a friendly nation; 2nd, To protect the lives and property of United States citizens in danger from mobs or insurrections within the territory of a friendly nation; 3rd, To call the attention of another nation to the immediate necessity of arranging differences, or to warn foreign citizens against the performance of arbitrary acts injurious to United States commercial rights; 4th, To aid in obtaining a correct knowledge of the waters and coasts of the world by means of

exploring and surveying expeditions, and to aid and extend the interests of commerce.

The first circumstance is one of constant liability in the United States, owing to the cosmopolitan character of its inhabitants and, in a measure, to the popular idea of American born people that foreign insurrections are invariably revolutions of people bound down by monarchical oppression from which there is no other way of escape, thus calling for the active sympathy of a great and self-ruling people. Let disturbances arise in any country and active supporters of it will be found in the United States, who, either through a lack of responsibility arising from their unnaturalized condition, or through a misunderstanding of the principles of liberty, upon which the government is founded, will not hesitate to perform overt acts in violation of international amity. The disturbed condition of Ireland presents such a situation to-day. Cuba, Hayti, Mexico, Central America, France, Italy, Hungary and so on in the list, back to the birth of the country, furnish repeated instances of the necessity for the use of naval vessels by the United States to prevent violations of the laws of amity. The natural desire of mankind to resent in person injuries inflicted gives rise to a necessity for naval vessels to prevent the commission of acts of reprisal. It is but a few months since this danger arose from the arbitrary acts of citizens of Newfoundland in attacking American fishermen. Vessels of war were required on the banks to prevent reprisals by our citizens, which would have complicated the questions raised by the original difficulty. Contingencies of a similar nature may be safely predicted, but their exact form cannot be surmised. Vessels of war must be in readiness to meet them on the instant that they occur.

The second circumstance is one of constant occurrence; the lawlessness and violence of mobs requiring immediate aid for peaceable citizens. Although the danger may be foreseen and provided for in time, where insurrections occur in civilized countries, the case is reversed in semi-civilized nations. The third circumstance, although approaching a condition of imperfect amity, is often of the greatest use in preserving peace. Examples of the necessity and the efficacy of an exhibition of force have repeatedly occurred in the relations of the United States with Spain. It occurred at the time of the French occupation of Mexico; again in the settlement of a question with the Bey of Tripoli, but a few years ago; in Mexico, Venezuela, and the South Sea Islands. All governments are subject at times to the

baneful influences of unreflecting passion, demagogic conceit, or arbitrary ambition, and when questions arise between nations, however reasonable the demands of one may be, an exhibition of a determination to uphold its rights, even at the hazard of war, is liable to become necessary when the other is subject to one of these influences. It is but a few months since Spanish vessels of war stopped and searched commercial vessels of the United States, in direct violation of the laws of amity, and, although the acts were disavowed by Spain, vessels of war were made necessary to visit Cuban waters as a visible warning to the colonial officers not to repeat an offence that they had judged would be condoned by their superiors.

The fourth circumstance is of constant existence. Dependence cannot be placed either upon private enterprise or foreign research to obtain the information necessary for the maintenance and development of commerce. Both naval personnel and matériel, in whatever form they exist, are best fitted for carrying on the necessary work.

Having thus established the existence of necessities for naval vessels, under all conditions of the country, the next step is to determine the importance of and amount of variation in the services required. The past history of the United States, and the well established policy of non-interference with the affairs of foreign nations, give firm ground for the assertion that the normal condition of the nation is one of either perfect amity or neutrality; therefore the composition of the standing navy must be such as will primarily satisfy the conditions imposed by these circumstances. Under all circumstances requiring actions of restraint towards people within territorial limits, (internal insurrections excepted, which require separate examination), the necessity for naval vessels is subordinate to other means of restraint and no formidable strength is required, since no naval strength exists to oppose to it. In these cases, therefore, unarmored vessels of moderate dimensions suited to the requirements of cruisers are sufficient to fulfil the purpose. Since however these duties require the pursuit and arrest of escaping vessels, these cruisers must be given power to sustain a high rate of speed for a great distance. In order to prevent citizens from committing acts of reprisal, the same conditions hold; fighting power is not necessary but great speed is all-important. With regard to attempts made by foreign naval vessels to use United States territory as a base of operations or to violate neutrality by trespass, it may be safely asserted that a simple warning or protest would almost inevitably suffice. But naval vessels are neces-

sary to give this warning, and to enable them to properly do the service they must be cruisers capable of policing the ocean territory of the country and keeping at sea for protracted periods. Insurrections and rebellions in foreign countries or wars between nations are of constant occurrence, and when they break out naval vessels are immediately required to afford an asylum for United States citizens and property in danger. This service cannot be performed by merchant vessels for two excellent reasons: 1st, they do not form a part of the inviolable territory of the United States nor are they authorised to act directly for the government; 2nd, they lack the power to resist lawless attacks upon them and are themselves in need of protection. The duties of naval vessels in these cases are peaceful in their nature and require no more of an exhibition of strength than is necessary to guard against lawless acts. Hence for such services unarmored cruisers of moderate dimensions are sufficient. In the cases of outbreaks in semi-civilized countries, although the object of the required service is peaceful, a positive exhibition of strength is necessary in order to overawe the mobs, since peaceful negotiations are of themselves no guarantee of safety. None of these nations or provinces, however, except Turkey and Egypt, possess a naval force of even moderate strength and their seaports are poorly defended. In addition to this, an uprising, although it may only affect the citizens of one foreign nation, invariably brings at once the vessels of war of several others to the threatened point, all united in supporting the common cause of civilization. Unarmored vessels therefore are capable of furnishing sufficient strength to meet the necessities, although much of the result depends upon size and actual power of the vessels.

Although wars may be foreseen and the exigencies be provided for at comparative leisure, insurrections and individual acts of violence can never be long foretold. Hence the necessity for squadrons of cruisers in time of peace, ready to act at any threatened point at short notice, and, from what has preceded, these squadrons may be composed of unarmored vessels, mainly of moderate dimensions, and, on stations comprising the territories of semi-civilized nations, having a few of the heavier classes.

There remain the cases of a necessity to prevent an unjust interference by a belligerent in the rights of neutral commerce, and the circumstance of calling the attention of a foreign power to the immediate necessity of arranging differences. Both of these circumstances call for the services of vessels of war only after the failure of a protest

through the diplomatic department of the government; and the bringing forward of naval vessels is in both cases an act clearly bordering on one of war. Much therefore depends upon the course adopted by the government concerned. The policy of the United States is, as has been already stated, one of extreme reserve as to foreign affairs, and in its execution repeated examples may be given showing that the fact that circumstances are such that there is simply a danger of an unjust interference in the rights of neutral commerce is not considered sufficient to justify the use of a naval force; indeed it is questionable if even a strong protest would be considered politic against anything short of an overt act. To make this point clear (and it is necessary so to do in order to determine the requisite naval strength) the actions of the British and United States governments are cited with regard to affairs on the coast of Spain in 1873. In that year the Spanish government was engaged in suppressing insurrections in its southern provinces. The insurgents gained possession of several men-of-war, and, hoisting the red flag, an unrecognized ensign, cruised along the coast levying tribute on the seaports and Spanish merchant vessels. The Vittoria and Almansa were captured by a British iron-clad squadron, under the plea that, although they had not interfered directly with British commerce, they had endangered its rights. The act of the British Admiral was upheld by his government. United States war vessels were on that coast and the national commerce was subjected to the same risks from the lawless acts of the "Intransigentes," but orders were issued by the government, on no account to interfere except an overt act were committed. An act of a very similar nature was performed by a British admiral on the coast of Peru some years afterward. Such being the policy of Great Britain, and nearly all maritime nations possessing armored vessels, the necessity exists for that country to have armored cruisers in peace as well as in war; and, with equal truth, the opposite policy of the United States does away with the necessity for such vessels in time of peace.

The necessity has repeatedly arisen for the United States to make a display of naval strength to call the attention of Spain to the urgency of matters of dispute between the two countries. Such displays, however, only occur after overt hostile acts by Spaniards, and a stringent restraint is always placed upon the proceedings of the fleet. That peaceful negotiations have but glossed over without remedying the evils is a patent fact, and it is equally patent that the possession of a naval force of ten times the strength would not add anything to the satisfac-

tion of the case. Herein lies the weakness of the argument of those who advocate powerful fleets for the United States. That a prompt recognition of the rights of the United States commerce in Cuban waters demanded a few years ago a display of force, of both armored and unarmored vessels, no one acquainted with the circumstances is disposed to deny; but, if it be the policy of the government to permit the safety of commerce to be jeopardized, and to sacrifice commercial interests by seeking unsatisfactory remedies, then the necessities for a navy in such cases, either do not exist, or, if existing, are of secondary importance. The United States, whatever be its policy, must have a navy to aid in sustaining the neutrality and belligerent rights of other nations, as the non-maintenance of one brings a risk of war. She either needs or does not need a navy for the protection of her own interests, according to whether her policy is to support or neglect those interests. Experience shows, however, that at times the government considers it necessary to make a display of force, and as this brings about a strained condition liable to lead to war, a certain element of armored strength is required for the emergency.

In accordance with these analyses then, it has been established that for the standing navy in time of peace or neutrality an active force of unarmored vessels is necessary, proportioned in number to the amount of interests at home and abroad requiring protection. Cruising stations for squadrons are necessary in those parts of the world affected by United States commercial intercourse. Vessels of a medium class are mainly required and these vessels must possess a maximum of speed and capacity for fuel; they must also be provided with full sail-powers, not only as a matter of cruising economy but to enable them to keep the sea for long continued periods. On certain stations these medium vessels must be supplemented by cruisers of the heavier classes. Finally, the navy must possess a certain passive force of the stronger or armored element.

No demonstration is necessary to prove that a naval force must be stronger in time of war than during peace. These peace forces must then, when taken together, serve as a nucleus of the war strength, their power and type being such as will at the same time best fulfil the peace demands and serve the defensive war purposes until a proper war strength can be developed. Since the range in general types of unarmored vessels is quite limited the discussion of the modifications demanded by a state of war may be postponed for the present; but with armored vessels, the great range in types and the normal passive

condition which renders the war modifications paramount, make an especial discussion of these war necessities imperative.

It may be stated as an axiom that for coast-defence and the prevention or breaking up of blockades, armored vessels of what are universally recognized as coast-defence types are the ones most necessary. For the protection of commerce and attacks on an enemy's commerce the armored vessel is not needed. The crippling of the enemy's naval force, may or may not necessitate the use of armored vessels according to the especial object sought to be accomplished. If the enemy's iron-clads appear upon the United States coast, then coast-defence iron-clads are required to meet them. If the enemy's iron-clads cruise at large on the ocean, it is contended that the better policy would be to let them alone. To send iron-clads in search of them would be an undertaking expensive, hazardous, and unsatisfactory. Commercial vessels are in no more danger from them than from unarmored ships and must accept great risks at any rate. If the enemy chooses to waste strength in sending armored vessels on indefinite cruises to cover an immense ocean territory, a false ambition to meet him in hand to hand encounter should certainly not lead the government to follow the example and put great strength where it can do little good. If the enemy's iron-clads attempt to break blockades established, then armored vessels are necessary to frustrate the attempt. In examining the circumstances of these blockades, it is found that Mexico and Central America possess no iron-clads, therefore armored vessels are not urgently required there. Brazil, Argentine Confederation, and Chili possess them, therefore, owing to the great distance of the ports from home, cruising iron clads would be necessary to success. The vicinity of Florida and South Carolina to Cuba and the weakness of the Spanish fleet, combined with the great distance of its home ports, make coast-defence iron-clads thoroughly competent to establish a blockade of its ports. It is confidently asserted that Jamaica and the British West Indies are safe from blockades by the United States, on account of the paramount necessity for the use of the full armored strength in the defence of the coast in case of war with Great Britain. Canada is equally free from blockade dangers for the same reason. Bermuda might be captured, it could not be successfully blockaded. With regard to European ports, an attempted blockade by the United States would be both impolitic and improbable, on account of the lack of a base and the necessity for crossing the ocean only to meet fleets in good condition fresh from

port. With Japan or China, strict blockades would be more expensive and less satisfactory than a system of worrying dashes by unarmored vessels.

Thus, of all the necessities of attack and defense, the blockade of South American ports alone calls imperatively for the use of the cruising iron-clad. A blockade of these ports appears itself imperative, since the prosperity of these countries depends in a very great degree upon a free communication with European Nations. For a passive force then these types are entirely unnecessary, and for an active one the probable necessity is either so slight or so vaguely defined that these types should be left for the war pressure itself to define. In thus condemning the sea-going or cruising types of armored vessels as far as the United States is concerned, more convincing argument still is considered necessary to satisfy the ideas of those who are attracted by the courses adopted in great foreign navies. In the first place, full weight must be given to the exigencies arising in European states from endeavors to preserve the balance of power. These render a condition of peace one of an extremely precarious nature, thus calling for a greater interdependence in type development. The natural desire of Italy, for example, is without doubt to limit the strength of her navy to coast defence types; but her peculiar position in the Mediterranean requires that to maintain her situation as one of the great powers, these coast defence vessels should be of a strength to give her a commanding position in Mediterranean affairs. Her Duilios and Lepantos must oppose an effective barrier against the too vigorous assertions of power of the Inflexibles and Duperrés. The United States fears nothing from the latter vessels except in actual war. Italy must fear their domination in the diplomatic actions of peace.

Policies in different nations are extremely changeable, and their instability not only demands greater peace strength but the slight necessities of one day become serious the next, therefore greater range in type developments is necessary. Ten years ago the imperial policy of France called for foreign cruisers; in two years' time the Republic demanded coast-defence; to-day its demands are general and in a year no one can prophesy what they will be. Ten years ago Russia had no navy in the Black Sea; to-day she is developing her power there and peaceful relations with the rest of Europe are kept at a constant strain. Prussia has become the German Empire with greatly extended coast to defend and enhanced responsibilities as one of the balancing powers of Europe. The policy of great Britain, that nation

that prides itself on its stability, is as changeable as that of any in Europe. Radicals and Conservatives are equally patriotic, and yet in foreign affairs the paths followed by each as it comes into power could scarcely diverge farther, and in nothing is the foreign policy of Great Britain more faithfully reflected than in the successive type developments of its fleet.

Strong navies in close proximity to each other cause again this great interdependence. To none of these circumstances is the United States subject. She is as a great power isolated from foreign political complications. Her policy as far as other nations is concerned is unchangeable and the policies of other nations do not effect her. The circumstances giving rise to necessities for a navy being of a constant nature, the range in types may be reduced to a minimum; and since these necessities are mainly of a defensive character, then the type of armored vessels should also be one suited to coast defence.

Thus far the analysis of the needs of the United States has led to a limitation in the range of armored types from which a choice may be made by excluding those vessels that are generally known as cruising iron-clads. In pursuance of this line of argument the next step is to ascertain what general types of coast defense vessels should or may be excluded, and to determine this point the conditions which a state of defence will force upon the country must first be established. The general problem may be thus stated; Given, a certain amount of armored strength as a mass, how shall it be distributed in order to best defend the coast from threatened or actual attack?

The United States coast, taken as a whole, is in what may be considered a fairly excellent condition of navigability; by this is meant that there are no great stretches so protected by shoals or dangerous passages as to render them difficult of access to an enemy's force. This whole coast must be defended, since scattered along its entire length are sea-ports of great commercial importance. An examination of the general conformation will make at once apparent a peculiarity which should exercise a great influence in the limitation of the type of armored coast-defence vessels. The coast is divided naturally into a series of districts or basins within whose limits inter-communication is readily obtained, but which are so separated from each other as to render it difficult to send vessels rapidly from a point in one to any threatened point in another. These basins may be arbitrarily named as follows: 1st, the Gulf of Maine, limited on one side by the New Brunswick boundary and on the other by the outlying islands and

banks off Cape Cod. 2nd, the North Atlantic, comprising the great bight between Narragansett Bay and Cape Hatteras. 3d, the South Eastern or Carolina, including the crescent between Hatteras and Key West. 4th, the Gulf, from the Florida Keys to the Rio Grande. 5th, the California, from San Diego to Cape Medocino. 6th, the North-Western, from Mendocino to Vancouver. The Alaskan coast is omitted from consideration owing to its present lack of commercial importance.

In the case of a threatened attack from the eastward, it is plain that no estimate could be made as to the point aimed at by a force mustered at Halifax, Bermuda or the West Indies. Although it may be known that an attack in force is contemplated, the point at which it is to be made would only be ascertained through the appearance of the force on the coast. If such an attack were contemplated, it would either be in force, that is, made by an armored squadron, or in a series of running dashes at different important points by single vessels. The first method is only to be feared from Great Britain, France or Spain, as other nations lack the base to work from, and even in these cases a fleet attack is a matter of such magnitude that it could hardly be expected to take place during the first periods of a war. The second may be feared from any nation having armored cruisers, and may be reasonably expected in the first periods of war. The probability being so much the greater in this case must be the first one provided for. The first aim in the development of the defence then should be to prevent such attacks, and, if they cannot be wholly prevented, to break their force.

Owing to this distinctive division of the coast into basins, if a single armored cruiser should suddenly appear off Boston, vessels stationed in New York bay would be debarred from coming to the rescue in time by the necessity of rounding Cape Cod and threading the channels of the Banks. Vessels on the Atlantic coast are powerless to offer rapid relief from attacks in the Gulf. Charleston and Port Royal cannot well be defended from Hampton Roads and vice versa; whilst the defence of the Pacific is entirely separated from that of the Atlantic. Since the coast is so broken and so extensive as to give an advantage to attacking vessels by retarding those sent to the relief, it is certain that the total defensive power cannot be massed in a single heavy vessel. There must be a division into at least six independent parts, the strength of each part being so regulated and distributed as to offer an effective menace against individual assaults within its basin, without immediate reference to that of another.

The magnitude of a thoroughly effective defence may be estimated, as being equal to the sum of the strengths of one armored vessel stationed at each threatened point, the power of such vessels singly being equal to that of the cruiser likely to make the attack. As the points are numerous, the number of vessels and the total power would be very great. Such a total would however represent a war footing, and since the normal condition of the United States is one of peace or neutrality, the constant maintenance of so great a strength is necessary. The peace strength should be just so much as would make it a great risk for single armored vessels to visit the coast during the first periods of war, holding them back until opportunity is given to establish auxiliary harbor-defence and to bring forward the war strength. In order to arrive at this minimum, the risks to which each basin is exposed will be considered separately.

The north-western basin is in the least danger from naval attacks, it being highly improbable that any armored vessel except one from Great Britain, would go so far from its own base of supplies to make an attack that would under no circumstances have other than a local effect. The main risk is then reduced to the chance of a war with Great Britain, in which case Vancouver offers a great vantage ground for attacks all along the Pacific coast. In accordance with our assumed standard of strength, the points in danger in this basin are:—Port Townsend, the key to the de Fuca straits and the sound; Olympia, the head-quarters of the Puget Sound defence, and the Columbia river. Of these three points, the dangerous bar of the Columbia combined with the merely local effect of an attack there, reduces the liability of attack to almost nothing. No attack can be made on Puget Sound without first overcoming the defending force in the straits; therefore the total strength assigned to the defence of this basin is truly represented by the power assigned to Port Townsend.

The British armored force on the Pacific coast has never exceeded one armored vessel which could only be reinforced within a reasonable time by one other iron-clad detached from the China seas. It is evident that the holding of Esquimalt would be of the first importance to Great Britain, since without it operations by an armored squadron or even by single iron-clads would be next to impossible. A force in the straits therefore that should menace the safety of Esquimalt would be a protection to both the North Western and the California basins since it would necessitate the immediate presence of the British force at that point, and the risk of attacks on California being thus reduced, a

certain amount of dependence may be placed upon a reinforcement from that basin. The peace strength necessary then, need only be sufficient to attack Esquimalt with impunity in the absence of an armored enemy, and since the whole fighting ground is limited to a narrow inland water this force may be represented by the strength of a single harbor-defence vessel of moderate power. The presence of this much strength in those waters will *insure* the immediate presence of the whole British armored force at that point, and the exact position of the enemy being known, reinforcement may be given from the California district intelligently.

How shall the strength be distributed? To force the enemy's armored vessels to come north, this strength must be so arranged as to threaten seriously the Esquimalt shore defences, with power to damage if not destroy the dockyard. To hold a large force by a small one it must be so much lighter in draught than the British cruising iron-clad as to enable it to take up a secure inshore position for defence pending a reinforcement that shall permit offensive operations against the enemy's armored vessel. Its general measurements should, however, be sufficiently great to permit of a transfer of the force to the California basin in case the war be with any other nation than Great Britain.

The first requisite of the force excludes from consideration, the Chinese Alpha class of gunboats for harbor-defence, the Ram pure and simple, and the torpedo vessels. Neither of these types can offer a serious menace to shore defences. Plainly then, this strength must be concentrated in a gun-bearing, armored, vessel. Power of artillery must take precedence of number of guns, and her armor must be of the greatest resisting power consistent with the character of the vessel. The character and position of the shore defences demand a calibre of rifled guns not less than nine inches, and these guns must be wholly protected, thus excluding barbette fire. These limitations point directly to the pure monitor type of vessel as being the most suitable. The draught of water must be less than eighteen feet (allowing twenty feet for the minimum draught of English armored cruisers) and experience shows that it should be greater than eleven feet to give her qualities that would enable her to make safely the passage from Puget sound to San Francisco. One more feature requires consideration as tending to limit the power required. Although there is no harbor-defence vessel permanently stationed at Esquimalt it may safely be prophesied that in accordance with British policy, one will be sent there

in the near future, and since its object would be solely to protect the harbor in case of war with the United States the main effective strength of the navy will not be weakened to provide for this single contingency, and this vessel will probably not be of a greater if as great a strength as the "Cerberus" type. A United States vessel then of an equal strength will relieve the whole Pacific coast from danger of attack by armored vessels in the first periods of a war with Great Britain. Before entering upon a discussion of the necessary details of the type, the requirements of other basins will be determined.

The California basin is exposed to attacks from Great Britain, Chili and Japan; the points immediately endangered from single ship attacks being San Francisco and San Diego, the latter point being destined from its position as a great commercial terminus to offer in the near future great temptations to assault.

Two other points are endangered from later operations, although measurably safe during the opening war periods. Monterey bay and the Santa Barbara islands in the hands of the enemy would form excellent bases for naval operations within the basin. Their defence may, however, be left to the later development owing to the necessity for the enemy to mass a considerable force to take and hold the position, or, in other words, it would enter into the measure of the necessary war-strength. The danger of attacks from Chili or Japan on San Francisco may be met thoroughly by the transfer of the force delegated to Puget Sound to that point, since the north western basin is not endangered. Time and opportunity would under all circumstances be sufficiently ample for the purpose. In the case of war with either of these nations therefore the question of defence is reduced to that of San Diego. With regard to Great Britain, it has already been demonstrated that pending the development of a war strength, their armored force may be kept clear of this district by the importance of the interests to be defended by them farther north. To keep them north, however, the armored force of this district must be depended upon.

The magnitude of this relieving force must be sufficient not only to hold a British harbor-defence vessel and an iron-clad cruiser north, but also if possible to confine the freedom of action of the reinforcement from China, forcing a concentration of the enemy's strength instead of allowing it to spread along the whole Pacific coast. Since the iron-clad detailed to draw the enemy north is of only a sufficient strength to neutralize the British harbor-defence vessel, the relieving force must be of a greater total strength. The nature of the service

required demands an armored coast-defence force. Shall it be concentrated in a single vessel or be divided? A single heavy iron-clad would in actual combat possibly represent a sufficient total strength, but in such a combat the probability would be great of having two vessels matched against three, giving the enemy the advantage not only of artillery power but of tactical manœuvring and ramming facilities. Furthermore, the exact demands of the attack and the defence cannot be foreseen. By having a force so concentrated, a superfluity of strength may be sent to one point at the expense of the defence of another. If the force be divided between two vessels, one may be sent north at the first demand, leaving the other to combat an attempt at a diversion. At the outbreak of war suppose one of these vessels to be stationed or to proceed directly to San Diego and the other to remain at San Francisco. With the help of the shore defences these points are safe from attacks by the armored cruiser which must proceed north. As this cruiser leaves the California basin, San Diego becomes relieved from danger, as a vessel coming from China is in no condition to make an attack so far south. She may attempt San Francisco, in which case a harbor-defence vessel is there to meet her. The enemy then has a choice between two courses, either to remain in front of San Francisco blockading this lighter armored vessel or to go to the defence of Esquimalt and thus permit the whole force to concentrate at the north. For the defence of the California basin then two armored vessels of the monitor type are sufficient, and in order that the interests of economy may be considered, it is estimated that one of these vessels may be of the same measurements as the one detailed for the north western basin whilst the other may come within the limits of a light harbor-defence vessel, the limitations being given in the discussion of details.

The Gulf district is in reality open to attacks from the armored cruisers of all European nations, but its naturally protected position combined with the meagreness of results to be obtained by individual attacks reduces the probability of them almost to a nullity so far as armored cruisers are concerned, in all cases except those of wars with England, France or Spain, whose West Indian possessions enable them to strike with equal facility the Gulf or the Atlantic basins. The points that are liable to menace are; Galveston, the mouth of the Mississippi, Mobile, Pensacola and the Florida Keys. Of these, Galveston offers no inducement for the expenditure of armored strength at such a great distance from a base; Mobile is protected by its shal-

low channels and interior position; the mouth of the Mississippi presents but one narrow channel available for sudden attack and this channel may be quickly placed in a condition of secure defence from individual attacks by means of earth-works and torpedoes. Pensacola, as a dock-yard station, offers a temptation for assault sufficient to demand a separate defence. The Florida Keys, being in fact the key to the basin, demand the most attention, as their seizure by an enemy would give him a control of the whole southern coast.

In case of a war with Spain, the vicinity of Cuba to the coast, and the importance of this island to the kingdom, render an attack in force upon it the best method of protecting the whole Atlantic from assault. For a blockade of Cuba, the Florida Keys are of the highest importance as a base of operations, and the whole force of the basin may in this case be treated as one concentrated at this point. It has already been demonstrated that the iron-clad force detailed for this blockade may safely be limited to coast-defence types, and, in view of the limited peace strength permissible, the number of vessels required for a blockade and the condition of the Spanish armored force, these coast defence vessels are most effective if the whole force be divided amongst light armored vessels, a certain amount of dependence being placed upon a reinforcement from the more northern basins, and this dependence is allowable since the main efforts of Spain must be directed to saving Cuba, leaving no spare force for creating a diversion.

If the war be with France it would seem that since the possession of St. Pierre and Miquelon at the north would enable iron-clads to menace the northern basins and thus deprive the south of reinforcement; and the vicinity of the West Indian colonies gives a fair base for action against the southern coast, the main objective point of the French would be the seizure of the Florida Keys which would give them entire control of the Gulf basin and a foothold for attack on the Carolina coast. In this case then, the whole action in this basin is concentrated to the defence of the Keys, and no relief can be planned by an attack on the French possessions, since such an attack would require the use of the greater part if not all of the peace strength devoted to the Atlantic, drawing it too far from the points requiring defence. The same conditions hold, and with greater force, in case of war with Great Britain, with a great risk to Pensacola in addition.

These being the conditions, it is considered that one light iron-clad monitor should be detailed, for the defence of Pensacola in case of war with Great Britain, for a reinforcement of the force at Key West

in case of war with France, or for a menace against Havanah in case of war with Spain; two light monitors for the defence of Tortugas and two more for Key West, giving thus a total for the patrol of the islands that would deter single vessels from attempting a seizure, and a number sufficient to make a good distribution about the Cuban coast pending operations on a greater scale.

The Carolina basin presents no point for obtaining an advantageous foothold by an enemy and four points only under a liability to attack, Wilmington, Port Royal, Charleston and Savannah. Of these, Wilmington and Savannah are self-defending against attacks by individual vessels. A detail of one light monitor for each of the other two points is considered sufficient to deter attacks on them, whilst they may both be used against Cuba with safety. In fact the vicinity of Port Royal to Charleston and the strong shore defence that may be established at that point would permit of sending one of these vessels to the Keys in a war with either France or England, giving them thus five and perhaps six vessels with which to keep the command of the Florida channel and gulf. It may be asked: Why are monitors arbitrarily named as the type of vessels? The answer to this question is that although reasons may be given for even a preference for the ram or the torpedo vessels in a strictly defensive warfare, the probability of war with Spain is greater than that of any other nation. In such a war a blockade of Cuba and seizure of the island is undoubtedly the first step to be taken, and such a step requires the use of armored gun-bearing vessels, and due weight must be given to these limitations in arranging for the defence of the Keys. A type that shall fulfil reasonably all the requirements is preferable to one that may be better for one object but which is totally unfit to meet the strongest probability.

The North Atlantic basin, from its great commercial importance and general accessibility, offers the greatest temptation to attack. Its great distance from any of the foreign colonies forbids offensive measures as a means of protection, as has been cited with regard to Vancouver and Cuba. The force employed must therefore be one of a strictly defensive character, although here, the fact that one half of the dock-yards of the country are within this basin and the central position of the district making it the grand supply and relief depot for the other basins, should exercise a great control in type limitations. The points endangered are; Nantucket whose seizure would give an enemy a most complete base of operations against the whole coast;

Narragansett bay and the eastern entrance of Long Island Sound; New York bay, Delaware bay, and Chesapeake bay. Of these, the naval defences of Delaware and Chesapeake bays are in a position to offer mutual reinforcement, for the following reasons; an attack on Lewes or the Delaware breakwater would only be made with the object of holding it as a base, as nothing is to be gained by a dash at it. An attempt to hold it would be met by a concentration of force sent from the other parts of the basin. Beyond Lewes, no point offers temptation for attack short of Wilmington, and since the presence of the enemy would be known upon his reaching the capes, any operation high up the bay would lead him into a "*cul de sac*," sufficient time being allowed for the despatch of a force from the Chesapeake. Richmond and Washington, on account of their riverine position, may be rapidly placed in security by means of earthworks and torpedoes, whilst Baltimore is similarly situated to Wilmington. Norfolk alone presents a point on which attack may be made with a chance of getting away safely again and even here torpedo defence is applicable. For a strict defence of these positions it may be asserted with much reason that torpedo boats at Wilmington and Norfolk would suffice. This style of defence however would not suffice to keep a single cruiser from patrolling the mouth of the bay and stopping communication with the dock-yards. The ocean highway must be kept at least passably free in the interests of supply and relief of other basins. The armored ram pure and simple might make the risk of keeping an armored cruiser just outside too great to warrant its attempt; but the greatest present probability of war is with Spain, and this event would call for armored gun bearing vessels. In any event it is considered impolitic to sacrifice artillery power entirely to the ram. Since the service of the Delaware bay force is confined to driving cruisers from the vicinity of those waters, it is considered that two light monitors may successfully perform the work, a certain dependence being placed on the defence of the Chesapeake in case points high up the bay are threatened. The same amount of force would suffice in Hampton Roads were it not that the chances of an attack on Norfolk are very great and in any event a reserve must be held for the Delaware. If this reserve consists of one monitor of medium class, the combined force of this and two light monitors would give the advantage to the defence in any individual attack, whilst in a war with Spain this heavier monitor and two light ones could be spared for West Indian service.

The position of Nantucket makes it indisputably the key to both the Atlantic and Gulf of Maine basins. The great commercial importance of New York renders that point especially susceptible to attack, but such an attack, it is contended, to be of any real service to the enemy, must be in force, since it is to be expected that the defending force will be strong in proportion to the importance of the metropolis. In case of a war with either Great Britain or France, no point offers such temptation as Nantucket. A dash by a single armored cruiser supported by a few corvettes and gun boats may result in the capture of the island, and once in the hands of the enemy, it would not only be a difficult matter to recapture it, but the position would establish a complete control over New York and Boston. The importance of the defence delegated to the navy is strikingly exemplified in this case. Vessels of war of the enemy cannot hold points on the mainland as the facilities for a shore defence are almost unlimited. At Nantucket however success by the enemy is secured by the vigilance of a naval force in patrolling the captured waters. It is considered then that in case of a war with either of the above mentioned nations a constant naval defence must be retained at Nantucket and the position of the island demands for the main naval strength at least one armored gun-bearing vessel. If this vessel be a monitor of a medium power, its presence will warn off the enemy's single cruisers from this point. If the cruiser attacks Narragansett bay, the force from Nantucket and Long Island Sound may be quickly concentrated there. If he attacks the Sound the Nantucket force may come to the relief. New York bay, from its distance and position, must have an independent defence. Owing to the position of Narragansett bay between Nantucket and the Sound and the presence of the torpedo station making it natural for an enemy to expect a strong torpedo defence, it is considered sufficient to leave this point to this auxiliary force. The confinement of the eastern entrance of the Sound and the vicinity of Nantucket makes it possible to reduce the defence of this point to two light monitors, thus giving a force strong enough to check an attack pending the arrival of reinforcement, whilst Narragansett or Nantucket may receive reinforcements if they be attacked without leaving the Sound entirely open in case of a feint on the other points. Let it be remembered that a feint on points west of Nantucket although possibly leading to a withdrawal of the force from that point would not only catch the feinting vessel between two fires but would lead to a rapid and certain joining of the whole defending force for a recapture if Nantucket were lost. For this reason

the Nantucket defence is concentrated in a single vessel whilst that of the Sound is divided.

The position of New York bay, removed from the possibility of a quick reinforcement from the other parts of the basin, and the importance of the point to be defended, demands both a strong defence and a concentration of power. In order to ward off individual attacks effectively it is considered that the least strength that can be detailed for this point would be represented by two medium class monitors, and this disposition, whilst securing the port itself, would permit operations tending to keep the whole bight clear of cruisers by the aid of the threatening position of the defending vessels at Nantucket, the Sound, and Delaware bay.

In the case of a war with any nation except Great Britain it is considered that but three points in the Gulf of Maine basin offer temptations to attack; these are Portland, Portsmouth and Boston. No point in this basin would be available for establishing a base of operations against the coast since Cape Cod effectually breaks the connection. In case of war with Great Britain, the Maine coast may be threatened by operations in conjunction with measures for invasion from New Brunswick. In this case, however, mere attacks on the verge of the coast would be unsatisfactory, and the risk from torpedoes and earthworks is considered sufficient to keep iron-clad cruisers from the rivers. The armored defence, then, may be considered as confined to these three points. The immediate harbor defence of Boston may be safely entrusted to auxiliary defences, but since communication with the city may be blocked by a single cruiser patrolling the waters between Marblehead and Cohasset, it is considered that two light monitors are necessary to insure the clearance of this point. Portsmouth is a point of greater importance to the defence than Portland, and owing to the position of its dockyard rendering the latter assailable and subject to damage by an attacking vessel without entering the Piscataqua river, it is considered that one medium class monitor is required at this point, not alone to secure it, but to afford a quick concentration for the relief of Boston and Portland and to add to the individual weight required as protection for this basin which is so isolated from more southern points. Such a vessel offers also a strong protection to Nantucket, in connection with the vessel stationed there, and those at the Sound and New York. Finally, since Portland offers no thorough defence through torpedoes and shore works, and in view of the self-dependence thrown on this basin for its total defence, a force of one light monitor is considered necessary for this point.

The discussion with regard to types of armored vessels best suited to the needs of the United States has taken the ground that owing to the geographical and political position of the country, the types should be limited to coast defence vessels; and, owing to the limitation of total requisite strength brought about by the normal peaceful condition of the country, this power, in the interests of economy, should be divided principally amongst light harbor-defence vessels. These vessels should be able to support heavy guns and armor on account of the services required in beating off armored cruisers, and certain sea-going qualities are demanded; 1st, in the Pacific, on account of the necessity of making passages between San Diego, the Santa Barbara Islands, San Francisco and Puget Sound; 2nd, in the Gulf, for the patrol of the Florida Keys and the blockade of Cuba; 3rd, in the Atlantic basin, for the reciprocal support between Delaware and Chesapeake bays and for the defence and reinforcement of Nantucket; 4th, in the Gulf of Maine, on account of the isolation of the basin and the necessity for a quick concentration at certain points. Great weight of armor and artillery, combined with a fair modicum of sea-going power, is best combined in the monitor type of vessels and it is with the details of this type that the final discussion will deal.

In the generally accepted classification of coast-defence vessels, those known as light armored vessels are such as do not exceed a displacement of two thousand tons. There are in the United States Navy now many monitors of the original type coming within the prescribed limit of displacement tonnage, and, starting with these as a basis, it will be shown in what manner they may be modified to fulfil the present requirements. It is not the part of an essay to enter into the minutiæ of calculations, nor can fully detailed drawings and descriptions of a typical vessel find a place in such a monograph. In discussing the modifications, however, whilst no exact standard can be given by which to measure the correctness of the deductions, every point advanced may be substantiated sufficiently to prove its tenability, and such will be the course adopted. It is proposed to so modify these monitors as to give them an increase of artillery power, a greater command of artillery (height above water-line), an increase of freeboard to give them better sea-going qualities, an increase of armor protection, speed, manœuvring qualities, and ramming power; and all whilst keeping within the displacement limits.

The armament of the 1900 ton monitors consists of two fifteen-inch smooth-bores with their attachments. In view of the work

which such vessels will have to perform, these guns should if possible be replaced by long ten inch steel breech-loading rifles; that is, by guns capable of piercing a fourteen inch wrought iron plate at five hundred yards. The long rifle must be a breech-loader, in order to keep the size of turret within reasonable bounds and to give proper loading facilities. The results of the proof firings of foreign guns, and the development of steel manufacture, point to the necessity of using this metal as the construction material. Finally, whilst a power of penetration of fourteen inches at five hundred yards is sufficient to overcome the defensive strength of the majority of the cruising iron-clads afloat, it is considered to be considerably within the limit of a ten-inch gun of twenty-five calibres length; for the reason that, whilst the English short ten inch penetrates 12.7 inches at that distance, Krupp claims with his thirty calibre nine and a fourth inch gun to attain a penetration of sixteen and three-fourths inches.

The following comparison of weights shows that the substitution can be made, without calling in aid weight that is distributed elsewhere.

XV. Inch Smooth Bore.		Long 10 Inch Steel Rifle.	
2 Guns at 45,000 lbs.,	40 tons.	2 Guns at 41,000 lbs.,	36½ tons.
2 Carriages and slides at 18,000 lbs,	16 "	2 Carriages and slides at 21,000 lbs.,	19 "
100 Rounds, half shot and half shell at 507 lbs.,	22½ "	100 Rounds, chilled projectiles at 470 lbs.,	21 "
Total	78½ "	Total	76½ "

In this estimate the minimum weight is given to the smooth bores and the maximum to the rifles. Furthermore, the weight given to the rifle includes the appliances necessary for a center port pivoting carriage, and, since the length of the gun forbids the use of the present port-stoppers, the weight assigned to them may safely be allowed for the increase in the turret weight due to a reduction in the size of the port, it being proposed to abolish port-stoppers or shutters, this being the course adopted throughout Europe. The danger of disabling a gun by the jamming of a shutter is greater than that of the entry of a projectile into the port. The shot that would enter a port would smash or jam a shutter, whilst the same result may happen by a hit in the vicinity only of the port.

The present style of mounting a turret on a spindle is faulty in the extreme, and it is proposed to replace it by the turn-table system now in universal use, the increase in weight due to this change being esti-

mated as safely within two tons. Although the change in battery gives by estimate a saving of two tons, it will be in our estimate reserved as a margin for artillery, therefore by the change of turret mounting a weight of two tons is called for.

The 1900 ton monitor is designed for a mean height of deck above the water-line of eighteen inches. It is proposed to reduce this height to nothing by bringing the crown of the deck to the water-line, the side armor stopping also at this point. From the water-line it is proposed to carry up an iron unarmored freeboard fore and aft to a height of six feet, crowned by a wooden flush deck.

The reasons for the proposed reduction of height of armored deck are as follows. With the present height of eighteen inches, opportunity is given for a projectile striking at or just above the water line to open a serious leak underneath the armored deck into the submerged sections of the ship. In this case, the height of the between deck space decreases the dependence that may be placed in the reserve buoyancy of the vessel, no matter how thoroughly this part of the ship may be subdivided by water tight compartments; it brings the small but important additional strengthening due to the waterways and thickness of the deck too far above the water line to be of good service and it increases the size of the dangerous space laid bare in rolling and pitching. An increase of the freeboard permits this deck to be lowered by giving an increase of reserve buoyancy. Projectiles penetrating at or above the water line open water-courses into compartments where the minimum of evil effect is produced, since, being above water they are easily cleared, whilst the safety of the under water sections from flooding is preserved and their area is reduced. The slight increased protection offered by the deck against penetration of the side is carried down to the most vital point, and a material reduction in weight of side armor is effected. In the construction of all European iron-clads, these considerations lead to placing the armored deck even much lower down, it being generally found at or near the lower edge of the armor. In these monitors, however, the necessarily light draught giving a reduction of available height for boilers and engines, the probability that combats in which these vestake part will be in comparatively still water, and the small surplus of buoyancy allowed, necessitates fixing the height of the deck at the water-line, the water-ways being somewhat below in accordance with the round-up allowed to the deck.

In thus lowering the height of the armored side a material saving of

weight is realized, which may be estimated at one seventh of the total weight of side armor (this estimate allows an original total height of armor of seven feet, which is at least six inches more than is actually the case). The weight thus saved it is proposed to utilize in the construction of the unarmored superstructure or additional freeboard. As before stated this superstructure gives a clear freeboard of six feet all around. The iron for its construction may be $\frac{3}{8}$ of an inch in thickness, with a six inch wooden backing or skin, such a combination furnishing the strength necessary to meet the strains to which it would be subjected in a seaway, whilst the backing reduces the shattering effect of piercing projectiles. Assuming the thickness of the strip of armor that has been removed to be five inches, (in reality the average thickness is considerably greater), it will be found that only three-tenths of the weight is required for the iron plating; five-tenths is certainly an ample allowance for the angle iron frames, stringers, and light upper deck beams, leaving one-fifth of the weight to go towards making up the backing and the upper deck. This amount would without doubt suffice for the backing alone, but to make it certain the weight of the upper deck will be drawn from another source. The backing and sheathing of the armored deck it is proposed to leave in its present form, with the exception that, in place of the iron, steel two inch plates be introduced, whereby a saving of weight is gained which may be allowed to go into the backing of the superstructure, thus securing it from an under estimate.

As a matter of course, the turret must be raised to give a clear fire over this superstructure; that is, its height is increased six feet, and provision must be made for that much increase of armored protection about it. In mounting the turret it is proposed to adopt the French system rather than the English. That is, instead of having the turret mechanism protected by what may be termed an outside casemate, with a glacis at the joint, to make the turn-table smaller, resting it on the periphery of a second turret whose exterior diameter is slightly less than the interior of the turret proper, the latter resting on the rollers through the medium of a shelf-piece or ring around its interior lower part. The lower edge of the turret is carried down one foot lower than at present, covering the joint and protecting the rollers. The second turret, or, as it may be called, the casemate, since it is fixed and protects the space between the armored deck and the turret proper, should be of the same composition as the upper one. The weight of the turret proper as at present arranged is about a hundred and

ninety-six tons. Increasing its depth by one foot, to give the required protection to the joint gives an additional weight of twenty-two tons, whilst the weight of the casemate calculated in accordance with the measurements of the turrets is sixty tons; add to this two tons estimated for the change in the revolving mechanism, twelve tons for five water-tight bulkheads intended for the division of the superstructure, and twenty tons for the upper deck, and a total weight of a hundred and sixteen tons is reached, which must be drawn from some other source. It is intended to leave the weights and position of the pilot-house, smoke stack, air duct and accessories, above the armored deck, as at present.

In the discussion thus far, the weights considered have been disposed as would be found on a monitor of the Lehigh class, that is on a wooden hull. This hull absorbs, as near as can be estimated, somewhat over sixty-two per cent. of her entire displacement tonnage. The best European authorities give as the general weight of iron hull of monitor types of vessels from thirty-two to thirty-four per cent., falling in the case of the Javari, which is of the type under consideration but whose extremely flat bottom lightens the necessary weight considerably, to twenty-nine per cent. In the transformation of the Miantonomah, the hull is over-weighted, reaching fifty per cent. These lighter monitors however should certainly not pass forty per cent., and by making this the limit of weight, a saving is made in a two thousand ton vessel of four hundred and forty-four tons. This is a perfectly legitimate deduction, since the weights that have been treated of have been borne by United States monitors of eighteen hundred and twenty-one hundred tons, whose hulls by transformation from wood to iron, without alteration of the measurements, may be lightened the above amount of twenty-two per cent. Taking from this saving the accumulated one hundred and sixteen tons, a surplus of three hundred and twenty-four tons remains free for distribution.

Of this amount of spare weight, it is proposed to devote a hundred and forty tons to the engines, boilers and coal supply to give the vessel maximum speed of eleven and a half knots, with fuel for ten days steaming at ten knots. Sixty tons should go to the armor, which, taken in conjunction with a proposed alteration in the side armor, will permit the application of an upper strake over the middle third of the frames of seven inch compound steel and iron plates, diminishing forward and aft to five inch plates, with four inch steel plates at the extreme end sections. The lower strake of armor should be altered to

five inch compound plates with four inch steel forward and abaft the middle third. Finally, the turret armor may be made up of two five-inch plates with a six inch wood backing and a half inch skin plating. In this division, the weight of engines and boilers is increased by six per cent., the coal supply one per cent. and the armor as much as twenty per cent., leaving still a disposable weight of a hundred and twenty-four tons, which great surplus is left to cover all deficiences.

Doubtless this seeming assumption of rough estimates gives but little confidence in their truth. In an essay, however, a more extended particularization is scarcely permissible, and, to give a greater evidence that these estimates are within bounds, attention is drawn to the following points: 1st, an allowance of a hundred and twenty-four tons is made for differences of opinion as to the estimates of the weights cited; 2nd, the distribution of weights gives a heavier hull, lighter engines, boilers, and coal supply, and lighter armor than would be obtained by using the proportions of the displacement found in the average of European vessels of this type; 3rd, the type of vessel described has almost its exact counterpart in the Dutch monitors of the Guinea class, which have proved perfectly satisfactory after a test of from four to ten years.

One more modification requires attention. The elevation of the turret demands an alteration in the lines of the vessel with a view of retaining stability and steadiness in a sea way. The reduction in the height of the side armor compensates in a degree for this elevation of weight. For the general form of the hull, that adopted in the new Miantonomoh is proposed, gaining thus a well-proportioned and powerful ram. Whilst the length between perpendiculars and breadth of beam remain about the same as in the Lehigh class, the draught is increased one foot.

It is understood then, that the type of harbor-defence or light armored vessel proposed, is in general the same as the present United States single turreted monitor, the main alterations consisting in the elevation of the turret six feet, giving greater command of artillery fire in smooth water, and facilities for going safely into action in a seaway, the addition of an unarmored superstructure six feet in height, adding to the sea-going qualities by giving a better freeboard, furnishing better quarters for officers and crew, and by bringing them up above the armored deck, increasing the spare space below so that room is given for the necessary increase of engine and coal space; lowering the armored deck to a better position, and giving the vessel a ram and a more pronounced dead-rise.

The apparently weak point about this typical vessel is the unarmored superstructure, and since in the opinion of the writer of the essay it may be applied without endangering the safety of the vessel in action, a word in its defence is necessary. It is assumed that no seaman will deny that such a superstructure increases the sea-going qualities of the vessel, provided that the lines of the ship are so trimmed as to at least retain her original stability and steadiness, and certainly this is far within the limits of possibility. The danger from this superstructure is then entirely confined to the possibility of flooding it in action and destroying the reserve buoyancy. Now it is claimed that the maximum of defensive power has been given to the monitor from the water line down, which would not be materially increased by adding to it the weight allowed for the superstructure, which in any event would go more to strengthening the middle than the end sections. A projectile penetrating the side below the armored deck gives rise to the greatest possible danger, therefore it needs no demonstration to show that this deck should be placed as low down as possible, due regard being had to other requirements. In this respect then the addition of a superstructure permitting the bringing of this deck to the water-line increases the defensive strength of the vessel. It will be argued that if this superstructure be punched full of holes, the reserve buoyancy will be destroyed. Now it is argued that holes in it which are three feet above the water-line will not seriously endanger the buoyancy, except a combat be in a seaway that would seriously hamper if not entirely prevent an action. It is held therefore that the danger is limited to a strake three feet in height above the water-line. Now this superstructure weight has allowed for five transverse bulkheads, and it is claimed that allowing a shot coming in forward to pierce all five bulkheads, making such a gap that one of them could be filled in so short a time as two minutes, the resistance to the flow of the water offered by even remnants of the others, would permit those compartments to be kept easily free of water by steam pumps of ordinary power. To endanger the safety, therefore, all the compartments must be pierced, each by more than one shot. It is claimed that this will not happen in engagements between iron-clads, for the reason that the enemy will seek not to destroy these compartments but to strike the water-line, turret, steering gear and other vital parts. The truth of this assertion seems to be eminently supported by examining the results of actions between vessels happening within the past twenty years. It would seem as if the last action of the Huascar offered a fair example of the destruc-

tion that might be expected. This vessel was placed between two fires and sustained an action at close range for over an hour. She was disabled and captured, and yet her reserve buoyancy was not seriously threatened, although she presented a target not unlike the one proposed. In the melee of Lissa, the artillery fire did not endanger the buoyancy of any vessel in either fleet, although certainly some of the vessels were hit and pierced enough to satisfy the demands of any one. The only case in which the danger does occur is in a prolonged attack at short range on coast defences, and herein lies the basis of the whole argument. In the well-known discussion with regard to the Inflexible's lack of reserve stability, it was not her danger in fighting iron-clads that was feared but her weakness in sustaining prolonged attacks on shore defences. It was pointed out in a former portion of this essay that these light monitors are not intended for such work except as auxiliaries, their province being essentially ship-fighting; heavier iron-clads must be provided for dealing with the coast fortifications. It is contended therefore that the superstructure is under all circumstances a benefit and in no case a danger.

Since this arrangement of superstructure is faulty in the case of attacks on shore-defences, an expansion of the type in the heavier monitors will not prove satisfactory, and an alteration becomes necessary. In the opinion of the writer of this essay, all the qualities demanded of these heavier monitors are found most advantageously distributed in vessels copied without change from the Orion and Belleisle type of British iron-clad vessels, or, to use a name more generally known, in the Dreadnought class of vessels reduced. It is considered, although no calculations have been made to ensure the estimate, that by substituting compound steel and iron armor for the iron of the Belleisle, carrying in the casemate, so that it will barely enclose the turrets, transferring the pilot-house and mounting it on a spindle over the forward turret, abolishing the large glacis, made necessary by the system of muzzle loading, and substituting steel breech-loading twelve inch guns for the Woolwich type, such a reduction in weight will be made that the displacement may be reduced to forty-two hundred tons and the maximum draft to within eighteen feet.

These then constitute the types of iron-clad vessels best suited to the present needs of the United States. It is plain that none of the old iron-clads can be economically rebuilt to meet the requirements demanded, but, whilst these vessels still retain a semblance of strength, a wise system of construction will enable the substitution to be made

quietly, certainly, and without any appreciable increase in the yearly amount appropriated for constructional purposes. The following table shows the proposed peace strength and its distribution.

Name of Basin.	Needs of the Basin for Armored Vessels.	Armored Strength Detailed.			
		Number of Vessels.	Total Displacement Tonnage.	Per cent. of Total Force.	Artillery Power.
North Western and California.	To secure California coast ports from attack in case of war with Chili or Japan by having at each threatened point a vessel able to contend with the enemy. In case of war with Great Britain, to seriously menace the safety of Vancouver and to present a force sufficiently strong to cope with British armored strength in the Pacific.	3	10,400	16¼	Eight 12 inch, and two 10 inch B. L. Rifles.
Gulf.	To assume offensive operations speedily against Cuba in case of war with Spain. In a war with Great Britain or France to protect the naval stations of Pensacola and Key West, and prevent the enemy from seizing and holding the Florida Keys.	5	10,000	15¾	Ten 10 inch B. L. Rifles.
Carolina.	To protect Charleston and Port Royal from the raids of armored vessels and to reinforce the vessels detailed for the protection of the Florida Keys, or the blockade of Cuba.	2	4,000	6¼	Four 10 inch B. L. Rifles.
North Atlantic.	To prevent the enemy from seizing and holding Nantucket; to protect the naval establishments of Newport, New London New York, Philadelphia, Norfolk and Washington, to secure the safety of the commercial metropolis of the Country and to prevent armored cruisers from patrolling the most important basin of the whole coast.	10	28,800	45¼	Sixteen 12 in., and Twelve 10 in. B.L. Rifles.
Gulf of Maine.	To protect the naval station of Portsmouth, to prevent raids by armored vessels into this partially isolated but important basin, to aid in the defence of Nantucket, and in case of war with Great Britain or France to force the maintenance of a strong naval power at Halifax, or St. Pierre and Miquelon.	4	10,200	16	Four 12 inch, and four 10 inch B. L. Rifles.
	Total Peace Strength.	24	63,400		28 12 in. 32 10 in.

Displacement Tonnage of the existing armored strength, 52,360
" " armored strength on the Pacific coast, 3,500

The circumstances governing the general type limitations of the unarmored fleet have already been discussed, and it only remains to give the details of the modifications required to fit them for the present

needs. The total effective unarmored strength of the United States at the present time, including all steam vessels of a displacement exceeding three hundred tons, except the heavy navy yard tugs, is represented by fifty two steam vessels; and it is considered that, judging from the present squadron demands, the methods of cruising and relieving, and the yearly appropriations that may be depended upon, if these vessels were all in a condition to be made available within six months from any given time, they would be sufficient to fairly fulfil the necessities of foreign and home service. Since, however, the prolonged or arduous service under certain circumstances reduces the effectiveness of ships to such a degree that they are made unavailable for a year or more, it is considered that the full *cadre* of the navy list should not fall short of sixty vessels off the stocks, in order to realize a force of fifty vessels available within six months.

It has been demonstrated that this force should be mainly composed of vessels of a medium class, reinforced by a contingent of heavier vessels on certain squadrons where their services may be suddenly required. Since the main services of all these vessels are confined to the necessities of peace or neutrality, the element of economy must have great weight in the distribution of the force. Furthermore, the limited number of men allowed for the total active personnel exerts a great influence on the regulation of the displacement tonnage.

Of all the different stations occupied as cruising grounds by United States squadrons, the Mediterranean, Asiatic, and Home require in their complement at least one vessel of the heaviest class represented in the Navy, the first two squadrons on account of reasons heretofore given, the last because of the great probability that in case of a war or a disturbance threatening one, the Atlantic coast would become the theatre of the most immediate and active operations. In order that this representation shall be continuous, the number must be doubled in order to allow a relief vessel. The isolation of the Pacific coast and the strength of foreign squadrons kept in those waters demand an allowance of certainly one vessel capable of carrying the heaviest battery to be used by unarmored ships, and in the total complement one more is allowed to make up for loss of services due to repairs of over a year's duration. In this estimate, then, eight vessels are allowed for the highest tonnage, or about thirteen per cent. of the total number. It seems to be well established that vessels of the Minnesota class are too heavy for economical service, and the results obtained from the prolonged cruise of the Trenton seem to point to this vessel

as representing a satisfactory maximum weight. The course adopted in all foreign navies, as well as the teachings of the experience of the last twenty years in our own, distinctly point to the wisdom of having the main body of the Navy consist of vessels ranging in displacement tonnage between one thousand and twenty four hundred, that is, from ships of the Swatara class to those of the Alaska, and it is considered that whilst sixty per cent. of the force should consist of these vessels, the interests of economy and effectiveness are best served by having double the number of the lighter vessels, or, to give more exact limitations, to have twelve ships of from two thousand to twenty four hundred tons displacement, and twenty four of from eleven hundred to eighteen hundred tons. By this arrangement, there are left of our total force sixteen vessels for a tonnage of from six hundred to one thousand.

Taking the Trenton as a basis in the discussion of the modifications required, it is considered; 1st, that a greater effectiveness would be secured by reducing the calibres of her broadside battery and increasing the number of guns. Her battery, as it stands at present, has a calibre at least a half an inch greater than the average found in European vessels of a similar tonnage. In the development of smooth-bore ordnance, it was certainly a wise policy of the United States government to keep a high range of calibre even at a sacrifice of number of guns, but whilst the resisting power of the sides of unarmored vessels remains the same or in fact has become less, the great increase in power gained by the introduction of the rifled gun, has led to a possibility of overreaching the effective limit. This, it is considered, has been done in the case of the Trenton. Comparing her with the British Euryalus, it seems unquestionable that the sixteen seven inch guns of the latter vessel are superior in effectiveness to the eleven eight inch guns of the former. In a broadside action the Euryalus brings nine guns into action againt six of the Trenton's. It is suggested that for the gun-deck battery of this vessel ten long seven-inch steel breech-loading rifles be substituted for the eight-inch, thereby saving in weight at least three tons.

In order to secure a powerful bow-fire, arrangements are made on the Trenton for transporting the forward pair of main deck guns to forward ports, the bow-frames being given a flare out at the gun-deck, and the hawse-holes being carried down below the gun-deck beams. Any arrangement by which broadside guns must be shifted in order to command increased firing angle is faulty, in that it requires limitations

in the position of hatches, chains, galley, and other important adjuncts of a gun-deck outfit. Furthermore, as long as head-booms with their rigging are carried, no reasonably good bow-fire can be secured from the gun-deck. It is contended that all bow-fire belongs properly to the spar-deck equipment where only it can be made effective. It is suggested, therefore, that the hawse-pipes be restored to their normal position, and, whilst one port in addition to the bridle-port is left free for use in certain unforeseen contingencies of action, that the ten guns be put in broadside strictly with a view to their being fought in their proper ports.

In the arrangement of the spar-deck battery especial attention should be given to securing good fore and aft fire which is necessarily neglected on the gun-deck. In place of the present pair of eight-inch bow guns, which unquestionably over weight the extreme bow and give but a doubtful straight ahead fire, a single seven-inch is proposed, which will certainly have as great a command. By suppressing the channel-ways and setting the rigging up at the water-ways as is done in all French first and second rates, two seven-inch guns may be mounted in projecting half turrets just abaft the fore top-mast, backstays, giving a complete forward and beam fire without encumbering the gangways. Two other seven-inch guns should be mounted just forward of the mizzen rigging in the same manner, whilst abaft the mizzen-mast a single seven-inch pivot mounted amidships completes the after fire. With this disposition the Trenton secures the same broadside strength as the Euryalus, with an increased fore-and-aft command. With five more guns than are carried at present the total weight is not increased, nor is efficacy sacrificed. The bow-fire is reduced from a doubtful four gun command to a certain three gun one, whilst the bow itself is relieved from a great weight and the hawse-pipes are brought up to their proper position.

2nd. The ship herself should be built of iron, sheathed with wood and coppered, having a double bottom and wing passages. No explanation of the necessity of this modification is necessary.

3d. The weight saved by these modifications of hull and battery should be devoted to an increase of the horse power of the engines and the coal supply.

4th. A modification is urged as being of great importance, although hitherto it has received but slight attention in the United States. In all foreign men-of-war of the first or second class, it will be found that a bridge is erected forward of the foremast for the officer of the watch,

and on this bridge is placed the service steering wheel. By this arrangement those persons upon whom the whole safety of the ship depends at night are placed in a position where, under all circumstances, they may act intelligently. The officer of the watch has the helmsman and the binnacle compasses directly under his eyes, and is not obliged to depend either upon the vigilance of others for keeping a proper lookout forward, nor upon the watchfulness of a quarter-master in keeping a steady course. The suggestion of this modification, as having a direct bearing upon alteration in type, may appear superfluous, but since it deals with the removal of the steering-wheel from its time honored place at the mizzen-mast it is considered of sufficient account to be noticed, especially as it is liable to meet with opposition from those who are married to the old styles and principles. With the minor modifications influencing ventilation, light, cleanliness, and the general sanitary condition, it is considered the essay is not called upon to deal. The type of vessel, then, represented by the Trenton, with these modifications, is the one proposed for the heaviest rate.

It may be urged and doubtless will be with reason that there are many circumstances of action, especially against shore defences where the seven-inch rifle will be scarcely of sufficient power to accomplish desired ends. To meet these exigencies batteries containing this calibre must be provided, and it would seem that the next smaller rate of vessel offers good opportunity for the disposition. The Alaska is taken as the basis of this type, her counterpart being found in improved condition in the C class of British corvettes. These vessels like the heavier ones should be built of iron, sheathed, with double bottom and wing passages. It is proposed that the under water lines of these vesssels be kept as at present, their great excellence having been fully established. It is proposed that the top-gallant forecastle be lengthened somewhat in order to give galley room and increased berthing space. For the battery, it is proposed to mount a sixty-pdr. rifle on the forecastle as at present, just abaft the forecastle an eight-inch rifle pivot-gun, and a similar one on the quarter deck, eight six-and-a-half inch rifles in broadside, and at the break of the poop a modification is proposed having for its object an opening of the stern fire command with an increase of weight of broadside. The English method of accomplishing this result is by mounting a single seven-inch gun on turn-tables in the cabin, the quarter upper works being cut in to open the fire. There are two objections to this style. First;—it makes necessary the faulty shifting pivot, which in

this case is much more complicated than with the American system of swinging about a long slide. Second, it destroys a great amount of valuable space. It is now the general custom to decorate the quarters of all vessels with large quarter-galleries, which are no doubt greatly conducive to the comfort of the commanding officer. If, in place of these, similar uncovered galleries be built out on the spar-deck level at the break of the poop, room is given for the introduction of two sixty-pdr. rifles that will give a clear stern and beam fire. By this arrangement, whilst one less gun is carried than in the C class of corvettes, the same number of guns is given for a broadside with an increase of weight of metal due to a greater concentration of battery and a greater command of stern fire, whilst the eight-inch calibre necessary for heavy work is provided. All nations consider it of great importance to open a clear stern fire. The method adopted by the British is the one generally followed. In France however the poop-cabin is suppressed and a heavy center pivot rifle gives good all-around fire. In the United States Navy it is the invariable custom to completely block the stern and quarter fire by the poop-cabin. The method suggested above, it is urged, is practicable, and thoroughly accomplishes the object without a waste of space.

The next class of vessels is represented by the Essex, and since the size of this vessel especially adapts her for a commerce destroyer, which service, as was demonstrated, is one of the main war probabilities for the United States, her battery should be arranged with a special view to this service. For this reason it is proposed to develop the strength of bow-fire to the utmost, and to thoroughly accomplish this it is proposed to suppress the present forecastle pivot and heavy forward rifle pivot. In place of these guns, two sixty-pdr. rifles are proposed to be mounted in ports well forward of the fore rigging, the side forward being cut back sufficient to give a clear bow-fire. Abaft these guns, two six-and-a-half-inch rifles in broadside and on the quarter deck, two six-and-a-half-inch and two sixty-pdrs., the latter in galleries for opening the stern fire as heretofore described. This arrangement gives a good all-around fire and a maximum of broadside, whilst all guns are kept on the broadside carriages. These vessels should be of composite build, and it is proposed that a clear gangway shall reign from the steerages forward to the berth-deck. The galleys should both in this and the other spar-deck vessels go under the top-gallant forecastle.

The lowest class of vessels proposed should resemble in general type the next higher, a change being made in the disposition of battery corresponding with the services which their light draught is liable to impose upon them. Since the next higher class has a battery composed entirely of medium calibred guns, these smaller ones should fill the gap in weight of metal as is done by the second class with reference to the first. The battery proposed is, four sixty-pdrs, two forward and two aft, arranged as in the next higher class to open fore and aft fire, two seven-inch pivot rifles, one forward and one aft. These vessels should be composite built.

In this, then, is represented the total proposed unarmored fleet for general service. Although the bows of all should be heavily strengthened and provided with collision bulkheads as a preparation for a resort to ramming, the application of a forged snout is not recommended for any except the first class, the others not being able to carry it, on account of the fine lines forward and the necessity for securing as much buoyancy forward as possible. The assemblage of the force is represented in the following table.

UNARMORED FLEET.

Class.	Number of Vessels.	Limits of Displacement Tonnage.	Aggregate Tonnage.	Battery.
First	8	3800 to 4000	31200	Sixteen 7-Inch Long B. L. Rifles.
Second	12	2200 to 2400	27600	Two 8 " " " Eight 6½ " " " Three 60 pdr. " " "
Third	24	1300 to 1500	33600	Four 6½ " " " Four 60 pdr. " " "
Fourth	16	900 to 1100	16000	Two 7 " " " Four 60 pdr. " " "
Total	60		108400	

Present displacement tonnage of the unarmored fleet, 107,690.
Proposed Increase represented in eight additional vessels, 710 tons.

It may be considered that in view of the great increase in tonnage proposed for the armored fleet which is the passive one, the small supplement of 710 tons for a constantly active fleet is ridiculously small, but there are several considerations that must not be lost sight of: 1st, of the total present tonnage, a very large proportion is swallowed up in the vessels of the Wabash class which is a clear loss to the active force; 2nd, in this actual tonnage several vessels are counted which in reality have no business on the active list; 3d, in case of the sudden outbreak of war the unarmored fleet can be readily reinforced by vessels drawn from the merchant marine and new vessels can be quickly constructed; 4th, the unarmored fleet represents the offensive and the armored fleet the defensive strength of the country. To the latter then must be given the most thorough development. The first need of the country is for a secure defence, and, whilst, the small unarmored fleet is sufficient to prevent complications in time of peace, it is in this very time of peace that the armored defensive strength should be carefully and strongly developed, that it may form the strong backbone of the Navy, able to support the hastily constructed auxiliaries that a war would bring forth.

THE EFFECT OF GREAT COLD UPON MAGNETISM.

An investigation upon the magnetic condition of steel and upon the magnetic permeability of iron is now being made in the Physical Laboratory of Harvard University by Prof. John Trowbridge. The preliminary experiments are interesting, since they show that very low temperatures exercise a far greater influence on the magnetic condition than has been noticed by previous observers.

Wiedmann found that a bar of steel which was magnetized at 6°C or 8°C gave at 4°C and —25°C intensities represented by 5.08 and 4.90. This represents a loss of less than four per cent. In Trowbridge's experiments the bar magnetized at 20°C lost when subjected to a temperature of about 60°C a far greater per cent. In one case a bar magnetized to saturation lost sixty-six per cent. In another experiment the bar lost in forty-seven minutes nearly two thirds of its magnetism. After the same bar had been exposed for twenty four hours to the temperature at which it was magnetized its magnetic condition was fifty per cent. of its original state. The low temperature employed was produced by a mixture of solid carbonic acid and ether.

American Journal of Science, April, 1881, pg. 316.

C. E. M.

TRIAL OF A SECTIONAL 6.5 CM. MOUNTAIN HOWITZER.

This gun tested at Krupp's works was of the following dimensions:—calibre 65mm.; length 1,800mm.; length of bore 1,660mm.; weight including lock 180 kg; number of grooves, 12; depth of groove 1mm.; width of lands 2.5mm.; width of groove 14.5mm.; twist of groove, once in twenty-five calibres; total length of groove 1,625mm. The gun was divided into three parts, the breech with the lock, the chase, and the trunnion section, the two former being joined together by threads upon the latter. For convenience in transport, the piece is divided into two parts only, the trunnion section remaining attached to the chase; and either part may be transported on a single animal. The threads of the screws are protected from damage by brass caps, which screw on by hand. The carriage consists of side pieces of stamped sheet steel properly braced, with elevating screw, steel axle and wheels on the Thovet plan. The carriage ready for action weighs 181 kg.; it allows of 20° elevation and 8° depression to the piece. The charge used is 750 grms. of coarse grained cannon powder. The shell and shrapnel, 3.38 calibres in length, weigh 4.1 kg. The velocity, measured at 40m. from the muzzle, averaged about 394m. Each day of firing, the gun was taken apart and put together, requiring from fifteen to twenty-five seconds for the first operation, and thirty seconds for the last. In range and accuracy the gun was found very satisfactory; the mean range of eight shots, with an elevation of 6° 18′, being 2501.6m.

Translated from the Mittheilungen uber Gegenstande des Artillerie und Genie-Wesens, Fifth Part, 1880, by Prof. C. E. Munroe.

THE TYPE OF (I) ARMORED VESSEL, (II) CRUISER, BEST SUITED TO THE PRESENT NEEDS OF THE UNITED STATES.

By Lieut. Seaton Schroeder, U. S. N.

"In via virtute via nulla."

Mr. President and Gentlemen:—

The attention of this Institute has been invited to the naval defence of our country. At a time when public sentiment, as reflected in the leading papers, appears to be awakening to a sense of our necessities, a more interesting topic could not well be selected.

Of the two principal classes of vessels required to perform the extremely varied duties that devolve upon a fleet, we will first consider—

THE ARMORED VESSEL.

Some eighteen years ago Mr. Ericsson's uncanny looking production gave a most vigorous, almost a creative, impulse to a wave of revolution in naval warfare. That wave left our shores soon after, to ebb and flow in all the channels of human knowledge and ingenuity that so enlighten parts of the old world. It would ill become us, at this juncture, to close our eyes to the panorama spread before us, and remain insensible to the march of professional thought and the development of mechanical skill.

In Great Britain's magnificent, heterogeneous fleet, all the changes have been rung in the theory as well as practice of naval architecture, until one principle now seems to have been adopted, to which others are subordinated. While that country in her liberality has been carrying on experiments, even to the extent of subjecting one class to an ordeal ruder than is probable in war, many other nations have clung to earlier ideas, or sometimes have accepted the results obtained by their insular friends.

Different foreign policies regulate the cost of construction and maintenance of fleets; but the formation and geographical situation of coasts must have a voice in determining some points in the individual ships composing those fleets. Designers of vessels should first exam-

ine the special requirements for the protection of certain coasts. In all cases this does not seem to have been very carefully done. In the old world we see one country, centrally situated in the placid Mediterranean, whose naval administrators are vesting their means in huge floating targets, carrying guns at a height of thirty-two feet above the water. In the new world, whose shores, far from being washed by a placid sea, are noted as among the most dangerous in certain seasons, the naval defense is entrusted to vessels with thirty inches of freeboard, and guns about six feet from the water. True in the latter case great bays are found everywhere and shelters for unseaworthy craft are numerous, while in the former they are the exception. But, in the one case, the ability to obtain a plunging fire hardly seems to out-weigh the great cost and unwieldiness, while, in the other, the smallness of the target presented seems to be extreme when it results in helplessness in a sea way.

The coasts of the United States have twice the development of those of Italy, and sending a force from point to point in the Atlantic cannot always be done under as favorable circumstances as in the Mediterranean. Our isolation is often quoted as an element of defence, no powerful iron-clad being able to cross the ocean and have coal enough left on board to warrant blockading or attacking the ports or bays where our little monitors and torpedo-boats would harass them. That theory is fallacious, and the supporters of it must forget the convenient coaling and resting places that several nations have at our very threshhold. The only benefit derived from our isolation is that we are the less apt to be drawn into other nations' quarrels.

Whether we are to build vessels or not lies with our legislators. But, if the means are supplied, what we require is a vessel that can proceed in any weather from the Rio Grande to the St. Croix, and meet the enemy at any point. Build vessels with one inch free board and daring spirits will come to the front and take them to sea as they did eighteen years ago. But that does not prove it to be advisable. *C'est magnifique, mais ce n'est pas la guerre.* Our vessels may be needed to patrol the coast, or guard a port; they may be called upon to carry the war into Africa, if only to the extent of making a dash at some of those outlying ports that menace us in the southeast, or northeast; or their presence may, in the distant future, be required at the isthmus. Whatever be the duty allotted, they should be of such build as to leave port under any circumstances, weather a November gale, and meet the enemy on fair terms.

One great peculiarity in the formation of our coasts is most puzzling to the naval architect in his desire to derive increased benefit from it. The shallowness of the water in many ports is in itself a powerful element of defense, limiting, as it does, the number of possible points of attack by heavy vessels. It is certainly incumbent upon us to increase to the utmost the value of that advantage by giving our vessels as light draught as possible, without detriment to the other more necessary qualities of seaworthiness and speed. The fate of the late Independencia, when decoyed into shoal water by the Covadonga, emphasizes this recommendation, as it would leave the lighter vessel freer to manœuvre in action, and enable her occasionally to cut off corners in chase or flight.

With this one exception we have to be guided by much the same rules as in other countries. In trying to meet all requirements a broad field is open and many competitors have entered the lists, but the victors have yet to be proclaimed. The prime requisites may be said to be: seaworthiness, or ability to keep the seas for an extended period in fair weather or foul; speed sufficient to be able to repair quickly to any threatened point and cope successfully with the enemy; great offensive power, vested judiciously in heavy guns, the most approved torpedoes, and the ram supplemented by facility of evolution; defensive power, obtained by heavy armor, a double bottom and numerous water-tight compartments; light draught to as great extent as possible without detriment to other qualities. The main difficulty of the problem is in the harmonizing of these desiderata. Even leaving aside the, to us, most important question of economy, we see that the size necessary to develop perfectly the first two qualities is restricted by the desired light draught.

Displacement is certainly necessary to give the vessel hold on the water, speed, ability to carry the guns, coal and armor, and enough free board to ensure safety. It does not seem easy to fulfil the conditions with less weight than five to six thousand tons, which may seem large to our legislative and appropriating body, but is inconsiderable when compared with the vessels we may be called upon to meet.

Selection of the material for construction has of course an important bearing upon the problem, as a decrease in the weight of the hull will admit of having a less displacement or of increasing the coal supply. The art of working steel has not yet reached perfection, especially in this country, and we may not yet be able to effect the saving of twenty per cent. in the weight of the hull that is claimed by the use of that metal in lieu of iron. For the frame it is unquestion-

ably well adapted, and steel girders can be manufactured perfectly well in America. As regards the skin plating there is perhaps room for discussion, although it has been successfully tried in England, and will without doubt eventually supersede iron entirely. Pending the development of that industry it is advisable to use steel only for the frames. By accepting iron for the skin we err on the safe side in the matter of weight, and if able finally to substitute steel we will simply gain a few more tons of coal.

In these brief remarks on the material best adapted to the construction of armored vessels, wood has been entirely eschewed, and it seems hardly necessary to prepare arguments against the use of that material. In cruisers for the high seas there may possibly be some differences of opinion, but even our limited experience on this side of the Atlantic, the necessity that we have been under of reconstructing our wood-built iron clads, makes it needless to refer to more extended facts and figures. In the design of an armored vessel for our particular service we would even discard the wood and copper sheathing over the bottom. The general advantages of that species of protection against fouling are of course well known to all, as well as the disadvantages. In the special case under consideration, the desirability of limiting the draught, and the possession of fresh water rivers, where the vessels could remain the greater part of the time, seem rather to indicate the propriety of trusting to anti-fouling composition on the bare iron, and save the six per cent. additional weight of hull entailed by the wood sheathing.

Almost all admiralties have recognized the necessity of sea-worthiness, and therefore, of a considerable size. In this, also, as in all competitions for supremacy of any kind, an extreme has been reached by some of the contestants, and, having swelled the weight of war vessels to fourteen thousand tons, the tide will probably slack in that direction, and resume the more normal level indicated by the Agamemnon, Richelieu, *et al.*

Apart from the question of size, the divergence of opinions is still wide in regard to the protection of water-line and battery, shape of the hull and relative value of different weapons of attack. In England after many experiments and changes the revolving turret system has prevailed, supplemented by protection of only the central portion of the ship. The French seem wedded to the open-top turrets supplemented by complete water-line protection. The Russian fleet comprises a formidable belted turret vessel without a projecting ram. The fact of

the turrets having been taken out of another vessel of the Imperial fleet, in consequence of the disaster that befell the Captain, bespeaks a lessened confidence in that system, while the conduct at sea of the Czar's new "yacht" was, in the opinion of Sir E. J. Reed, "full of significance as regards the possible steadiness of gun-platforms in ships of war." Protection for the battery and complete exposure of the water-line, after passing through various stages in the Inflexible and Duilio, have finally reached a maximum in the Italia, which vessel in action will be not unlike a man facing a north wind with a fur coat and bare legs. In addition to these special features, we see hosts of casemate and central-citadel vessels in various parts of the world.

Each nation, it is presumed, has faith in the type it has selected, but that faith is truly "the substance of things hoped for, the evidence of things not seen." When the crash comes in European politics, that has been predicted for so long, some valuable lessons may perhaps be drawn. Practical experience in modern naval warfare has so far been scarce. As far back as 1866, in the Donnybrook Fair engagement off the island of Lissa, the difficulty was demonstrated of successfully ramming an enemy in motion. The same difficulty has been experienced on more than one occasion within the last four years, off the South American coast. On the other hand the destruction of the Rè d'Italia is not needed to illustrate the tremendous power of offence centred in the ram. The frequently unavailing efforts made by vessels of the same fleet to avoid annihilating each other by the involuntary use of that weapon, are but too eloquent.

Various deductions have been drawn in the armor question from the accounts of the Huascar's last struggle in Peruvian hands. One point certainly seems to be decided, and that is that armor, if not thick enough to keep projectiles out had better be abandoned where men are stationed, for it only serves to explode the shells which might otherwise merely pass through injuring only what they struck. The "*dèbris*" of the guns' crews found in the Huascar's turret, to borrow a graphic expression from a paper in the United Service, bore ghastly testimony to that fact and to the terrible localization of shell effect in such confined space. One great advantage that the Chilian vessels had over their plucky antagonist was in their ability to command all points of the horizon with their guns, emphasizing a need that had long been appreciated.

As a nation we are fond of our monitors, and have had faith in them since that memorable day in March, 1862, when Lieutenant Worden led

their pioneer to victory. And it is not without pardonable pride that we see the main features of the type accepted by the leading maritime nations, after some years of doubt. But we must remember that while we have been lying on our oars and resting after our great struggle, our trans-Atlantic cousins and other friends have been hard at work, and, by incessant study, research and experiment, have so improved upon our crude idea as to leave it barely recognisable in its reproductions. Having started the ball ourselves, and allowed others to keep it rolling to what must be well nigh the end of its course, we may now with good grace look about us and adopt ideas pertinent to this new iron age.

The advantages of the revolving turret system are the most complete protection of men and guns with a minimum weight, the self-support due to a circular form, the ability to fire toward every point of the horizon, the smallness of the target and rareness of its being struck with direct impact. This latter quality was the very *raison d' être* of the monitors.

As before stated in this essay, the insuperable objections to these as they are now built, are the insufficiency of freeboard, which causes a very small reserve of buoyancy and inability to use the guns in a moderately heavy sea; insufficient thickness of protective metal; insufficient weight of battery. That these last two defects were well appreciated by the boards of officers that examined the plans of the Terror, Amphitrite, Monadnock, and Puritan, was shown in their recommendations that a greater thickness of compound armor be given them, and that heavy rifles be substituted for their smooth bore guns. Carrying out these necessary recommendations will unfortunately lead to an increase of draught and displacement and decrease in speed and freeboard. The latter will be reduced to two and a half feet. That is not enough either for safety or ability to fight at sea. The same smallness of target offered by vital parts may be retained with a much greater freeboard. Protect the water-line, machinery, and guns, and the rest of the ship may be shot away without affecting the issue of the fight. By raising the turrets so as to fire from ten to twelve feet above water, the body of the vessel may be brought up correspondingly higher, greater safety insured, and comfortable quarters provided the officers and crew. To avoid carrying the side armor up high enough to protect the bases of the raised turrets, recourse has been had to a middle breastwork in several most formidable European vessels, and this plan seems to combine more good qualities than any other for a displacement of five thousand to six thousand tons.

With the preceding remarks in view we submit the following design for an armored vessel best suited to the present needs of the United States. The calculations are by approximate formulæ. More accurate computations may be made on preparation of the plans and slight alterations made when necessary.

In general terms the vessel we propose is a breastwork monitor. The lower body is protected by heavy armor from just above the water-line to five feet below, and is covered by a plated deck. The sides then rise to a height of seven feet fore and aft, having the shape and external appearance of an ordinary vessel. Within this hull a breastwork rises in the middle to the same height as the sides above the armored deck, enclosing the smoke stack, ventilators and two turrets, one at each extremity. These turrets are then seven feet above water and the guns about twelve feet, and the horizon will be swept by their fire as in our monitors. The bow will end in a spur supported and protected by the side armor, which will be brought down over it with a diminished thickness. The steel deck will also be sloped down to it for additional support and to afford protection against a raking fire from forward. The propulsion will be by steam entirely, and applied by twin screws so as to ensure rapidity of evolution. Speed, thirteen knots. Dimensions and other details are as follows:

Length between perpendiculars,	270 feet.
Extreme breadth,	60 "
Mean draught,	17 "
Displacement,	5,508 tons.
Indicated horse power,	4,030
Estimated speed,	13 knots.
Coal supply,	480 tons.
Engines,	Compound.
Screws,	Twin.
Ten-inch breech loading rifles, (or larger.)	Four.
Reserve of buoyancy, (about)	44 per cent.

The side armor consists of a middle belt one hundred and sixty feet long, from three inches above water to five feet below; thickness at top ten inches, tapering to six at the bottom. Forward and aft of this the thickness diminishes to four inches at the top and three inches below, coming down forward and covering the ram with a thickness of two inches. The upper edge of the forward and after belts also drops to the water line. The backing up of the side armor to be of Georgia pine, ten inches thick at the middle belt and seven inches for the rest. A two

and a half inch steel deck lies flush with the upper edge of side armor, covered with three inch planking. Forward this deck runs down to near the point of the ram, which protrudes six feet at eight feet under water; aft it also slopes down to three feet under water.

The breastwork, amidships, is one hundred and forty feet long and seven feet high above the steel deck. The width will be thirty four feet, external dimension, which leaves a gangway on each side, of about twelve feet. The armor plating on this breastwork is twelve inches, backed by ten inches of Georgia pine. The main deck within it is not plated, but the deck covering will be of steel two inches thick, and will form the glacis for the bases of the turrets.

These, rising from just within the circular ends of the breastwork, are nine feet high, twenty eight feet in exterior diameter, and mailed with twelve inches of armor with an equal thickness of wooden backing (pine). On top the forward turret is the pilot-house, eight feet in exterior diameter, seven feet high, with ten inches armor, and a half-inch iron mantlet.

The smokestack will be clad with ten inches of armor for a height of six feet above the breastwork, or thirteen feet from the water; and an air duct, one foot interior diameter, will be similarly protected to a height of four feet.

All armor will be compound, iron with about one-third the total thickness of steel facing. The only exception is the deck, which is wholly of steel.

The weights carried are approximately as follows:

Hull (steel frames, and iron skin below water)	1,653	tons.
Battery (four 25½ ton guns,)	102	"
Ordnance stores (ammunition, gun carriages and equipments,)	135	"
Engines and boilers, including water,	825	"
Side armor.	345	"
Armored breastwork,	740	"
" deck.	540	"
" turrets and pilot-house,	395	"
Wood backing and bolts,	90	"
Armored smokestack and air-duct,	50	"
Coal,	480	"
Anchors and chains, crew, effects and provisions, etc.,	150	"
	5,505	

A displacement of five thousand five hundred tons was not arbitrarily taken, but is the least with which it is possible to satisfy imperative conditions. Calculations for a less weight were commenced, and it was found necessary to increase the size until that figure was reached. Seventy per cent. was adopted as the coëfficient of fineness of the hull, which will be very slightly less full than our recently built monitors, but rather more so than the iron-clads recently built abroad. The individual tastes of nations in this matter seem very apparent;

Italia,	.591	Inflexible	.679
Duilio,	.637	Dreadnaught,	.697
Friedland.	.644	Miantonomoh,	.713
Amiral Duperré.	.656	Puritan,	.718

When, as in our case, it is strongly desirable to keep the draught within certain limits, some sacrifice has to be made in fineness of underwater body, for the displacement cannot be made up by length and breadth. There is a limit to the proportions of beam to draught for a vessel destined to see bad weather. The greatest innovation in that respect, the Livadia, may not yet be taken as proof positive of a successful idea. That she suffered no grave injury in her stormy trial is a notable tribute to the skill of the Clyde shipwrights, while the pounding of the waves on the bottom spoke loudly in condemnation of the principle as applied to sea-going ships.

In regard to the breastwork, there would undoubtedly be advantage in having it rise in continuation of the side-armor, as in the Dreadnaught. But the increase of weight would be such as to demand a greater displacement, with the inconveniences of greater cost and heavier draught.

Just a few details will give a sufficiently accurate idea of what we wish to produce.

The vessel will be built of steel with an iron skin, and will have a double bottom. One longitudinal and seven transverse water-tight bulk-heads will extend from the outer skin up to the deck at the water-line. These main compartments will be subdivided, as far as practicable, into a number of minor ones, also water-tight, and all of them, including the cells of the double bottom, will be provided with pipes to flood or free them as may be desired. There will be no overhang, for the reason that if broad enough to afford protection against ramming, it might prove a fruitful source of injury in a sea way.

The superstructure is not intended to contribute to the rigidity of

the hull, but must be made of such strength as to withstand the shock of the heaviest seas. Sharpshooters and the machine guns' crews will probably be stationed there in action, but the majority of the crew would, of course, be in the turrets and fire and engine rooms. A hand-rail will be fitted on deck, to unship easily and drop flat inboard.

The coal supply, limited to four hundred and eighty tons, will permit of none but compound engines. It is estimated by a liberal allowance (two and a half pounds per I. H. P. per hour) that that amount of fuel will drive her for a little over four days at thirteen knots. At the rate of ten knots an hour, it should last about ten days or twenty-four hundred miles; at eight knots, nineteen days or about thirty six hundred miles. A larger supply of coal would involve too great sacrifices in other points. A perfect ship of war is a practical impossibility. The one just described, under certain circumstances will labor under disadvantages; but, regard being had to all possible contingencies, we present the type as the most desirable for our navy.

CRUISERS.

In the design and construction of cruising vessels questions arise differing widely from those just discussed.

The contrariety of opinions formed and expressed in regard to the type best suited to our present needs are due to the varied conceptions of a cruiser's duty. In times of peace, men-of-war police the sea, execute surveys, and constitute schools of training for officers and men. But as these general duties can always be performed by whatever type may be selected, the whole matter hinges upon the question as to what service will be required of them when war, *ultima ratio regum*, follows unsuccessful arbitration. The various policies of attacking only the enemy's commerce, of resisting the advance of his iron clads, or of simply watching his cruisers, all have their advocates.

The object of a war is generally to enforce the cession of land, money, or a principle. Were we to devote our energies to preying on commercial vessels, we would undoubtedly make some valuable captures, which would make our enemy smart, but the smarting would be confined to the pockets of the few and the feelings of the many; the end of the war would be no nearer. As remarked by Admiral Jurien de la Gravière "the successful depredations of twenty Alabamas would not have delayed the fall of Richmond one day." We may add that one half that number combining to create a diversion or possibly raise,

for a few days, the blockade of one port, might have given a different coloring to some phases of the war.

A glance at the more practical points involved leads also to the conclusion that the policy of constructing war vessels simply to cope with merchantmen is erroneous. A high speed, equal to that of some of the trans-Atlantic packets, can only be attained by very large vessels. The horse power varying as the third, fourth, and fifth power of the speed, and as the two-thirds power of the displacement, it is the size of these vessels that makes their speed possible. It is their speed that makes their size profitable. A small vessel, however fast in smooth water, could never make much headway against seas that would only reduce the speed of an Arizona, Brittanic, or Orient to fifteen knots.

A perfectly efficient commerce-destroyer would therefore have to be very large and consequently very expensive, and, having less good fighting qualities, would have her sphere of additional usefulness limited to serving as a transport. A smaller and cheaper fighting ship, able to make only thirteen or fourteen knots in ordinary weather, instead of eighteen, could keep the seas for an extended period, possess handiness and a powerful battery, and also be able to overhaul ninety per cent. of the steamers now afloat. Moreover, those large and extraordinarily fast vessels, which, by the way, are mostly owned by one nation, whether employed as transports or supply vessels, would be apt to proceed under convoy if we were known to have vessels able to catch them. And if we had them the world would know it.

A modification of our present navigation laws would do much toward putting this question to rest. Far be it from our desire to discuss a matter that has assumed a political aspect of such serious import as to have been extensively shunned in the late presidential campaign. But were Congress to take the step of admitting foreign-built vessels to American registry, even under certain restrictions, not only would our mercantile steam marine receive a most invaluable impulse, but in the event of war our commerce destroyers, transports and despatch-boats would be in commission and practically equipped for this work, as they already are in other countries. With this in view, the thoughts of no one would revert to the idea of building men-of-war for other than fighting purposes.

By occupying the great maritime highways, encountering the enemy there, and striving to ensure safety for the carriers of our national and private property, the cruisers would perform the most important service that could be asked of them. They should have the power to es-

cape from a superior enemy, overhaul an inferior, and, with the help of Providence and stout hearts, capture or sink an equal.

How many of the vessels of other nations should be allowed to be superior is a practical question, depending upon the skill of our constructors and engineers and the liberality of Congress. Cruisers can be built carrying heavy armor and guns, and possessing great speed and enormous coal capacity. Such vessels could catch merchantmen and capture cruisers, but it would be using razors to cut blocks, a rather expensive waste of material. Most of the *soi disant* sea-going ironclads of Europe can undoubtedly keep the high seas, but not many will even be given that duty. It would cause their enemies too grim a satisfaction.

There are what are called armored cruisers, that is, vessels with sufficient thickness of metal at the water-line to keep out projectiles thrown by guns usually met with at sea. But their number is not great, and, according to present appearances, will not probably be increased. The expense of armoring vessels, combined with the detriment to other fighting qualities consequent upon the increased weight, is hardly commensurate with the advantages of so protecting them, if intended for work in distant seas. Devote the weight of the plating to a more powerful engine, greater coal supply and heavier battery, and the result would be a cheaper vessel, perhaps quite as useful. A vessel of this kind can successfully perform all services required of a cruiser, and, being less expensive, is in every respect of the type best suited to the probable wants of our navy.

As all the varied requirements of a war vessel conflict materially, both in the design and construction, it is a knotty point to decide to which should be given the greatest development. The prime elements of success are: speed, handiness, or ability to manœuvre rapidly under all circumstances of war, wind, or weather; power of self-support, that is to say, large capacity for stores, especially coal, and ability to economise the latter by the use of a full spread of canvas; the most effective offensive power. The words most effective are emphasized as in contradistinction to the often demanded greatest offensive power. The defense will rest solely in her power of offense, supplemented by perfected internal arrangements of water-tight compartments and placing the machinery as low as possible.

It seems rather unnecessary to discuss the importance of speed in naval battles. Suffice it here to weigh upon the facts that in fleet engagements the motions of all must be regulated by that of the slowest

vessel, either in proceeding to a point of attack, carrying out a plan of action, or frustrating an apparent plan of the enemy. In duels it is equally desirable, to risk or avoid action, to force action at whatever range may be most advantageous for a particularly constituted battery, or for extrication from an awkward position due to accident or ill-judged manœuvering.

The main difficulty encountered by the naval engineer in constructing engines of a required power is in the necessity of occupying as little space as possible in every direction, especially the vertical. Space is required for the crew, stores, ammunition, and coal, but paramount to all in an unarmored vessel is the absolute necessity of keeping the engines and boilers well below the water-line. This compactness is only obtained at the cost of a less economy in the application of power, which results in a greater consumption of fuel and the stowage of a correspondingly larger supply. In a heavy vessel not only is it a more simple problem to keep the machinery below water but the available space for coal is proportionately greater. The point to determine is that at which concessions to speed cease to be commensurate with the advantages.

For vessels whose occupation is simply in carrying cargoes between ports of a known depth, there now seems no immediate check to growth in size and engine power. The Great Eastern, prematurely built, will probably soon be matched, and many are the clairvoyants that tell of speeds to come far surpassing anything now known. With men-of-war it is different. If too large and unwieldy they lack that great quality of handiness so essential in action. If two expensive we cannot build enough, and would risk too many eggs in one basket.

In countries where the experiment has been tried, a very large size is looked upon with less favor now than at first. In this country, perhaps more than in others, does it seem desirable to fix a limit. Not all possible enemies have these ocean race boats, and, in the impossibility of foretelling from what point of the horizon the next war-cloud may approach, it behoves us so to organize and construct our modest fleet as to make the best of any circumstances that may arise.

Reviewing then our peculiar circumstances of smallness of appropriations and comparative isolation from scenes of diplomatic embroglio, we incline to making no greater concessions to speed than are necessary to ensure maintaining a steady rate of thirteen knots an hour for several days uninterruptedly, which will admit of perhaps fourteen over the measured mile. If in the space and for the same consumption

of fuel we can by mechanical skill obtain better results, so much the better. But that figure, while putting us at a very slight disadvantage if pitted against one or two particular nations, will leave us superior to the rest; and in the interim of peace our country will be better represented throughout the world, our commercial and other interests better served, the professional training of our *personnel* more surely perfected, and hydrographic work more extensively carried on by a certain number of such vessels than by a less number of faster ones.

Apart from the question of length and bulk, the handiness of a vessel is intimately connected and conflicting with the speed, in that it is best obtained by moderate proportions of length to breadth. In one direction the extreme ratio of eleven or twelve to one has been reached, in the other a nearly circular form still claims its advocates. Accepting the evidence of things seen we find proportions of 5 or 5½ to one have survived, as combining to the most satisfactory degree the two qualities we are discussing. With this shape a speed of fourteen knots can be obtained with a circle of evolution not disastrously great. Strength is also ensured, and good behavior in heavy weather.

In this connection it is important to decide upon the application of the propelling power. A twin-screw ship is well known to turn in a less space than a single screw. The farther advantages of the former lie in the facts that two engines in place of one would have to be disabled in order to cripple the ship; that the rudder and all the steering gear may be shot away, and the vessel be still quite manageable; and that the two screws give the best speed for the same expenditure of power. This last seems quite susceptible of explanation if we consider that the distance of the propellers from the run and deadwood allows them a freer supply of water and causes a less decrease of pressure under the stern, which is of course tantamount to a less increase of resistance under the bows. Taking the ratio of the indicated horse-power to the two-thirds power of the displacement as an index of the relative economy, Mr. W. H. White, in his Manual of Naval Architecture, states that "when steaming at a uniform rate of fourteen knots, the average ratio for the single-screw ships is about 17.5 as against 15.5 for the twin-screw ships, or about 11 per cent. in favor of the latter." The conclusion was arrived at after experiments carried on with vessels of the English navy, where even despatch-vessels are now being thus engined.

Over there also two-bladed propellers, capable of being lifted, have been successfully used, while in our service they seem to have lost

favor despite their many advantages. Whatever may be the merits of the case in single screw-ships, it is impossible, of course, with the double screws, to do better than let them revolve when under sail. But the good points cited above in favor of the latter, coupled with the freedom to have a longitudinal strengthening and water-tight bulkhead, ought surely to override the objections that they cannot be lifted and that they are somewhat more liable to injury from contact with wreckage or a friendly wharf. In action there is no question about it. The saving of perhaps fifty yards in the diameter of a circle of evolution may win the day, and we are not so rich as to afford to have one kind for service in peace, and another for fighting. A peace navy is an absurdity. All our vessels should be designed to give and take hard knocks, and the harder we give them the less hard we will get back. The twin-screw ship can unquestionably give harder knocks than the single screw.

The greater or less power of self-support at sea is in some respects a matter of detail rather than of type. Additional coal-bunkers may be put up at any time, regard being only had not to sink the vessel below her intended lines. If full-rigged, as all cruisers should be, so as to make good progress under sail, and to stay and to wear, it would simply lie with the commanding officer what top-hamper to strike in the event of encountering an enemy. For ordinary service full sail-power should be available, for the double purpose of effecting important economy and of affording instruction and exercise to the crew. A good man-of-war sailor is "handy" at anything, from a sail-needle to a 100-ton gun, and this is mainly due to his varied occupations and exercises. We should not lose sight of it in preparing his home. It is certainly noticeable, as a rule, that the most cheerful, contented, and healthy men are found in "smart" ships.

Finally come we to the interesting question of the most effective offensive power. In the selection of the battery we must again be guided by what service is expected of the ship. Armored vessels destined to fight walls of iron, stone, or earth must have heavy ordnance to accomplish anything. The guns of the Huascar in her engagement with the Chilian fleet were not any too powerful. But in that vessel's previous bout with the Shah and Amethyst, the same weight of metal vested in a greater number of smaller guns (protected from gatling fire) would have increased her chances of success.

In the absence of farther actual illustrations, let us suppose a vessel, T', armored to fight the Trenton and precisely similar to her in point

of speed, size, and handiness, and carrying the same four 8-inch rifles forward and one aft, but with ten of our old 9-inch smooth bores in place of the remaining six rifles. On sighting her enemy T' would immediately seek close quarters, and being of the same speed, could not be well denied it entirely. While approaching, her four rifles would match the Trenton's battery, and at close quarters the five nine-inch shell would have greater effect than the three eight-inch hurled at her. The greatest distance that the Trenton, by the best manœuvring, could refuse T' would be the diameter of their circle of evolution. What that diameter is, is not exactly known to us, but it should not be over four hundred to four hundred and fifty yards, and at that range the greater number of larger though lighter shots would outweigh disadvantages incident upon the wind.

In this case it would seem that smooth bore guns would have the best of it. But in the impossibility of being confined to certain cases in war, it would be wrong to put any but rifled ordnance in a cruiser. Were T, armed with ten eighty-pdr rifles in place of the smooth bores, her efficiency for ordinary service would be greater, as she might have to do with a faster vessel, or with one lightly armored. But while the guns used in chase or retreat should be heavy so as to be effective at long range, it seems desirable for the general purposes and probable circumstances of a cruiser to multiply the number of broadside shots at the cost of weight in the projectile. This seems to have been recognised in arming one of the most powerful vessels now afloat. The Amiral Duperré carries fourteen 5½-inch rifles mounted in broadside, besides the 13½-inch barbette guns. The vulnerability at the water-line of some recently built iron-clads may farther point the moral of that tale, and peppering the hull with a number of small shell may some day put the saving power of cork to a severe test.

Whatever the calibre of the guns, they should load at the breech. Increased power and precision, as well as protection to the loaders, are arguments to which all ordnance officers, however conservative, have had to bow, silenced if not convinced.

What is sometimes considered a disadvantage in thus increasing the number of guns, is that it also increases the number of men needed to work them. In some vessels that certainly is a tenable position. In the breastwork monitor, propelled entirely by steam, armed with guns worked by hydraulic power, built and commissioned solely for offensive warfare against ships or forts, the crew should be reduced to a minimum.

In a cruiser, whose multifarious duties include the training of seamen, surveying, manning prizes and sending boat and landing parties to the shore, it ceases to be an objection, and assumes the character of a desideratum. The increase in the number of men on a gun deck would barely be sufficient to warrant fears of a slaughter, unless they are exposed to Gatling fire. The machine-guns of recent invention have practically sealed the doom of the wide pivot ports universally found in our vessels, and as emphatically point to the necessity of protecting the crews of broadside guns, as well as the officers on the bridge, from the fire out of the enemy's tops. In other words, a spar deck should be adopted whenever practicable, apart from the benefits of having room to work while exercising or clearing ship for action. With that and the ability to load at the breech instead of the muzzle, the gunners would be practically free from small iron annoyance. The commanding officers will have to be provided with rifle-proof screens or pilot houses on the bridge.

An additional weapon of offense is found in the ram. That method of attack is as old as the hills, and the weapon interferes less than any with other qualities. In view of the possibility of the enemy's being armored, or perhaps having an iron or steel deck just below the water-line, it is necessary to deliver the blow under water. Great length of spur seems undesirable because of its consequent weakness and liability to be wrenched off, and because it is not generally necessary to pierce far into the body. Should the rammed vessel have a double bottom, the inner skin will seldom be over three and a half feet from the outer; and a six foot spur would seem ample to do great injury, and can also be made very strong. Should she be armored under water a depth of eight feet will suffice to clear it.

As for torpedoes, after a life of one hundred and four years they are still said to be in their infancy. The Harvey has been given up in despair by its staunchest advocates. The spar-torpedo, occasionally terribly successful when fitted to a small vessel especially built for it, is but a cumbrous nuisance in a large ship, and, with gear shot away by Hotchkiss or Nordenfeldt guns, is apt to prove a dangerous ally. The safest weapon is that which is least apt to 'return to its fold.' The Whitehead now seems to give the fairest promise, although only a small percentage of its trials have resulted in injury to the object of its attentions. In the absence of proof we can but accept promises, and with submarine warfare in its present stage it is advisable to fit ocean cruisers with tubes for discharging the Whitehead torpedo.

The type and general features of the vessel being decided upon, one item remains to be considered, which, although not affecting her immediate behavior under fire, is most important in the one thing that touches us to the quick. That thing is economy. The item is the material of which she should be built. Wood, iron, or both? Which shall be used?

A glance at statistical tables of cost of repair will perhaps be a more forcible argument than any against the farther use of wood. Cheap vessels we certainly must have, and when, by the use of metal, cheapness may be obtained in association with equal or greater strength and greater lightness, building vessels of wood seems no longer defensible. The immensely strong hull of the Devastation weighs, including the superstructure, less than thirty one per cent of the displacement, while in some old wood built armored ships the weight of the hull exceeded the weight carried. In the modern swift cruiser class the figure is about the same in the two cases, owing to the additional weight of wooden sheathing.

In the matter of fostering and developing our home industries, we would be guided toward building our national vessels, or at least their frames, of iron and steel.

To go somewhat into details we find that the advantages of an iron hull over a wooden one are: cheapness of repair, greater durability, increased lightness combined with greater strength. Disadvantages: more easy penetration of the bottom on taking the ground, fouling, greater discomfort and unhealthiness in a tropical climate, the shattering effect of projectiles. The fouling is best prevented, and the inconvenience and expense of frequent docking saved, by sheathing in wood and coppering. This is, unfortunately, open to the objections of materially increasing the weight, and in case of injury to the bottom, of probably admitting contact or galvanic connection between the two metals, under circumstances that might forbid examination and remedy, on the other hand, that system of protection, when carried up above water has the double advantage of making the vessel more comfortable and more healthy in very high or very low latitudes, and of diminishing the dangerous splintering in action. Now that rifled ordnance is in general use, this last objection obtains to a much less extent than when the blows were from spherical shell moving with a lower velocity. But it is still a point of some importance, and is best met by spacing the frames and sheathing the plates.

On examination of these various pros and cons, it quickly becomes ev-

vient that all the advantages arise from the iron framing, and the inconvenience from the iron skin. This suggests a composite build.

The difficulty in properly fastening wood and iron, and the fear of not obtaining equal structural strength, lead to hesitation in clothing the frame in wood. These are practical questions of mechanical skill and may perchance be solved satisfactorily. The expressions "good enough," "strong enough" have a slouchy sound, seeming to indicate a sort of careless self-sufficiency. But that such a thing is possible as to make a framework stronger than is necessary has been proven, notably in the original design of the marine ram proposed by Admiral Ammen. In that case eight longitudinal girders were discarded as superfluous.

The tensile and compressive strength of wood being so inferior to that of iron, and the effective sectional area (after driving bolts and rivets) of the planking being only about five-sevenths as great in proportion as that of the plating, there is no disputing that the former will contribute less than the latter to the general strength of the fabric. In vessels where the proportions of length to breadth are greater, and the natural strength consequently less than in the case under discussion, and when the number of horses' power required is nearly double the number of tons displacement, every detail must look to rigidity and strength of hull. According to recent reports, even the steel frames and skin of the Iris seem none too strong to stand the vibration caused by the development of such immense power. Not aiming at her marvellous speed, however, we will find a more moderate strength ample for our purposes, with the help of a longitudinal bulkhead, longitudinal frames, bilge kelsons, and string and shelf pieces, it seems quite possible to produce a rigidity equal to any demand in a vessel of the dimensions and speed here proposed. When, as stated by Mr. Reed, late Chief Constructor of the British Navy, a saving of one hundred and fifty tons weight could be effected in a mail steamer of twenty-seven hundred tons, by making the transverse frames subordinate to the longitudinal, it is certainly rational to expect, by developing longitudinal frames in combination with the ordinary transverse ones, an increase of strength sufficient to supply that of the iron skin.

By this composite build, then, we can secure economy and facility of repair, less liability to injury from grounding, less deadly effect from splinters on being struck in action, and, thanks to the non-conducting properties of wood, less cold in high latitudes and less heat in the tropics. The danger of imperfect insulation between the iron and

the outside copper is not so great as in the first days of this style of construction, and certainly less so than when an immense surface of plating lies hid. The experiment tried in a vessel recently built for U. S. Fish Commission, if successful, will show that by the use of rubber washers driven over the bolt-heads, one course of planking may be made effective. But whether one, two or three courses be laid, whether they be worked longitudinally, diagonally, or vertically, whether muntz metal or iron bolts be used, and whether the outside sheathing be of copper or zinc, are minor points hardly within the limits of our discussion.

Suffice it to present the following broad features of the cruiser suited to our present, and probable future, needs.

A composite-built hull, (iron, or steel frames, keelson and keel-plate, with wood keel and planking) with proportions of about five and a half to one of length to breadth, and laid down for a speed of fourteen knots. Displacement twenty-five hundred tons, or approximately that of the Benicia class, but with lines similar to the Swatara, which vessel has not her superior in behavior at sea. The engines to be compound, of sufficient power to drive the vessel fourteen knots an hour under favorable circumstances. They will be applied to twin screws, and it is recommended that they be provided with valves to admit of working them as simple engines, if desired, and that they have independent circulating pumps. Apart from their superiority *per se* there is a feature of these independent pumps that is well worth considering, viz: that they do not betray to an outsider the fact of the engine's having stopped or started, as is done by the out board delivery when they are connected with the engines and have to stop or start with them. On more than one occasion in our experience has the avoidance of collision been facilitated by thus knowing that the stranger had stopped. Desirable in a friendly meeting this would be the opposite in action, and it might be important to deny the enemy a knowledge which would dictate the way to put the helm in an attempt to ram.

The boilers should be fitted with automatic valves to prevent the flow of steam from one to another in case of injury by shot or otherwise. They must also be protected by coal laterally and from forward.

The battery, which is to be on a covered deck, will consist of breech-loading rifles;—two eight-inch in chase, and one of the same calibre aft, with eight six-inch in broadside. These, of course, will be supplemented by the usual machine guns for use aloft or on the rail.

The ram will not be a spur pointing forward from the body of the

vessel, but of such shape that the lines of the vessel will commence at its forward edge, as nearly as practicable, for the sake of strength and buoyancy. Above water the bows will continue to recede slightly as in the Alarm, though to a less extent, so as to throw the weight of the bow-chasers aft, and make the vessel lift more easily and ride drier in a head sea. The point of the ram should be about ten feet under water and eight feet forward. At the stern appearances must be sacrificed, and the counter brought well down so as to conceal if not protect the rudder-head.

In the matter of sails, a full ship-rig to royals should always be given a vessel of this size. The head-booms must be arranged to rig in and out easily.

Without going into minute details of what longitudinal framing is desirable, we will simply weigh upon the propriety of having stringer-plates or shelf-pieces on all the decks, but more especially on the berth deck where the greater force of a blow is apt to come in collision. In the absence of a heavy iron deck, which is one of the best protections against ramming, its properties would be partially found in a broad shelf piece just below the water line. One longitudinal bulkhead, extending from the stern port to the point of the ram, and seven or eight transverse, all water-tight, will add greatly to the structural strength and permit of isolating damages received. Farther water-tight subdivision in coal bunkers and elsewhere should be effected when practicable.

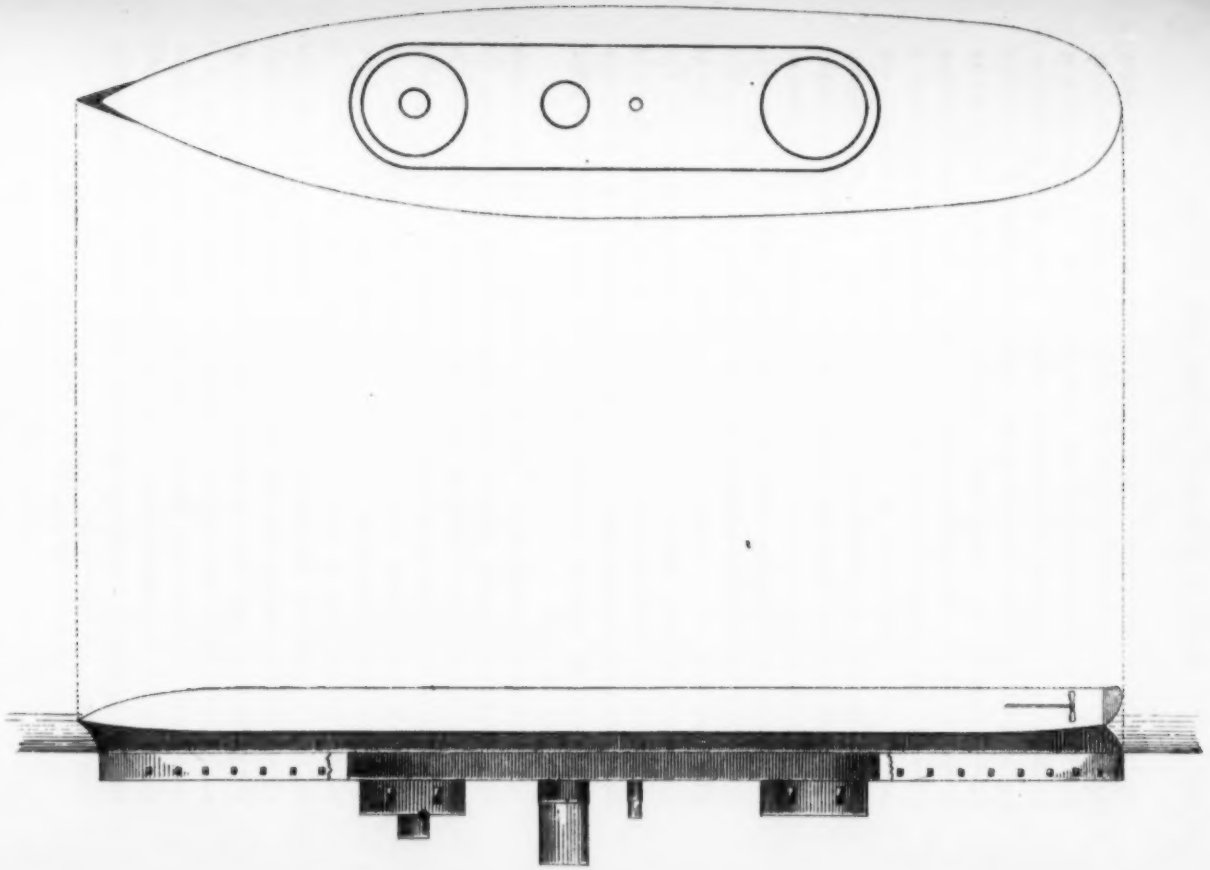
Smaller vessels than what we have proposed may be needed for special duty of various kinds, but they should constitute a separate class. The cruiser for ordinary service in peace or war should not be tampered with, nor attempts made to include such special work in their capabilities.

It would be well to build one in every four or five of a larger size, like the Trenton, to replace gradually our present flagships. These would be on the same general model, possessing perhaps a little better speed, and armed like the Trenton with the exception of the six eight-inch broadside guns, for which would be substituted ten six-inch.

The salient points of the type given, to which objection might be made, are the limited speed (probably thirteen knots for a steady rate at sea) and the light battery. It may seem that a faster steamer armed with a few guns of heavier calibre, would have our vessel at its mercy by keeping at such a distance as to leave only the heavy guns available. That is not so easy to do if our vessel keeps heading

straight for her adversary. Moreover when the distance of the target is greater than the ordinary range of our eight-inch rifles, the probability of hitting is very small. Still, let us suppose that the superiority of the faster vessel's range is a thousand yards. If the other keeps steering towards her, she must take to her heels to maintain a proper distance, and either be content with using her stern gun, or else make an occasional sheer to bring her broadside to bear. In the days of sailing ships the advisability of luffing to deliver a broadside in chase was a mooted point, even when the number of guns was so great, and the target, including a broad expanse of spars and sails, so tempting. Much less would it seem advantageous where the target is so small, the number of guns so much less, and the distance so much greater. In the case supposed the slower vessel advancing steadily at the rate of thirteen knots would make the thousand yards in less than two and a half minutes, which is not much time to bring by, point and fire at the bows of a vessel nearly two miles off, and head away again. The thirteen knot vessel would be pretty sure to get within the range of her two bow guns, and would then have the broadside of her antagonist for a target and the advantage of firing in a direction least influenced by the roll.

It is practically impossible for a vessel having even two knots better speed to remain out of range of light guns, and yet, by estimating the distance, be within the range of her own heavier ones. Advantage in speed, if not nullified by unwieldiness will certainly promote successful manœuvring when engaged, and our cruiser may not pretend to withstand everything afloat. Skirmishers do not generally attack forts, though the necessity of that deployment is none the less recognised in military operations. Our breastwork monitor, too, may be overmatched by a leviathan clad in two and three feet of iron and steel, and hurling projectiles that weigh a ton or more. Both might succumb in an unequal contest. But they will rarely have such odds. And it is thought that the one and the other will give a good account of themselves under any circumstances, for the spirits that move them will have recognised the truth of the motto that guided us in attempting this essay.



PROFESSIONAL NOTES.

These Articles have not been read before the Institute, but are inserted by direction of the Executive Committee.

REPAIRING A BROKEN CRANK WITH WIRE ROPE.

The following description of the temporary repairs made to the broken cranks of the U. S. S. Pensacola, by Passed Assistant Engineer Geo. W. Stivers, U. S. N., is interesting in showing what may be done with wire rope in the way of repairs on shipboard.

"The after crank of the forward engine only is shown, this one having been broken entirely across, but the plan adopted in banding both cranks of the after engine, which were broken nearly across, was precisely the same. The crank shaft and cranks were in one solid forging, and the fractures, were directly across the bodies of the cranks, between the crank pins and the shaft, as if following the plane of contact of fagots used in building up the cranks in the smithery.

For several months the existence of a very slight crack in the after crank of the forward engine was known, but frequent examinations failed to show any extension, and it was considered simply a surface flaw of no great consequence.

At about 5 P. M., June 18th, the ship being on her way from San Francisco to Puget Sound, it was found that this crack was extending rapidly. The weather was fine, sea smooth, and, with square sails set, the engines were slowed down, while preparations were made to strengthen the crank by temporary bands, so as to reach Victoria where it was expected that a heavy band could be forged and shrunk on.

The only iron that could be worked on board ship was a piece three and seven-eighths inches wide and three-fourths inch thick, and it was proposed to make of this two bands to embrace the crank side by side and to be set up by two 1-inch bolts on each side, passing through lugs formed by bending up and thickening the ends. The strength of the bands as straps was therefore only that of two 1-inch bolts, and their utter insufficiency was evident.

At about nine o'clock that night the crank had broken entirely across, but as the two parts moved together as usual, the irregular surfaces of the break and the long forward journal preventing their separation, the engines were kept slowly revolving until noon of the next day, when the plan of iron bands was abandoned, before being carried out, in favor of that which I had proposed, and the engines were stopped to allow its application.

Ten gutter pieces or shoes were made of an old iron grating and placed equidistant about the crank in order to keep the bottom turns of wire rope from spreading apart, when the riding turns came to be put on over them. The shoe at the extreme end and that on the butt of the crank only were secured in place by a small bolt through the center, the other shoe being held in proper position by hand until bound by the first turn or two of rope. Into the hubs of the crank a bolt one inch in diameter was tapped, to which the end of the rope was secured, and the work of wrapping the crank consisted simply in passing the wire rope continuously around the crank, hauling each turn taut by means of a heavy deck tackle passing down through the engine room hatch, and seizing each turn securely to the one immediately preceding it before slacking off the tackle. It was estimated that a tightening pull of about two tons was brought on each turn of rope, and the seizing of the separate turns having been done very expertly, there was no slacking back of the wire rope during the progress of the whole work.

In this manner eleven turns of the rope were put around the crank side by side, just filling up the space between the jaws of the shoes, then over these were put the riding turns, and over these again nine more riding turns, making altogether thirty turns of wire rope encircling the crank. The finishing end was simply passed around the banding at one of the shoes and stopped as shown in the sketch.

The wire rope used in this work was of nine-sixteenths inch diameter, consisting of five strands of seventeen wires each, arranged about a central hemp core of three-sixteenths inch diameter, the wires being of number nineteen wire guage. The work of banding this crank was completed in seven hours, and just as it was finished, it was found that both the cranks of the after engine were broken nearly across, the cracks extending entirely through each crank and to within about an inch of each side in about the same direction and relative position as in the forward crank. This discovery caused the abandonment of the attempt to reach Victoria, the ship was headed to the southward with

the intention of returning as best we could to San Francisco under sail, and, the banding of the forward crank having been so satisfactorily accomplished, it was decided to strengthen the after crank in the same manner, so that the engines might be used in case of emergency.

This was done and, when about two hundred miles from San Francisco, the wind blowing lightly from ahead and sails being useless, the engines were started and worked continuously without stopping for over forty-five hours until the anchor was dropped in the harbor of San Francisco. During this time forty-five thousand eight hundred and thirty-five revolutions were made, an average of 16.85 revolutions per minute, and an average speed made of 4.41 knots per hour under steam alone. The next day the ship was steamed up to the Mare Island Navy Yard, 26 miles from San Francisco, the engines being stopped and started seventeen times during the run to allow target practice, and upon arrival at the yard the rope banding was found to be as firm and unyielding as when first put on the cranks.

The speed at which the engines were run with these fractured cranks was low, for the weather was fine and no necessity required the taking of the least risk; the initial pressure above zero on the pistons was twenty pounds, cutting off at nine inches, there being two cylinders sixty inches diameter and thirty-six inches stroke; yet it is evident from a calculation of the strength of the banding on the extreme after crank which transmits the power of both engines and which would have been strengthened if more wire rope had been at hand, that a considerably greater speed could have been safely attained.

The gutter pieces or shoes were, it will be seen, indispensable to the successful application of the wire rope banding, for they prevented the first course of rope from spreading under the pressure of the riding turns; they allowed the driving of iron wedges beneath them without injury to the rope, in case it should become slack and require tightening and they permitted the passing of the end of the rope between the crank and the whole banding so as to secure it firmly.

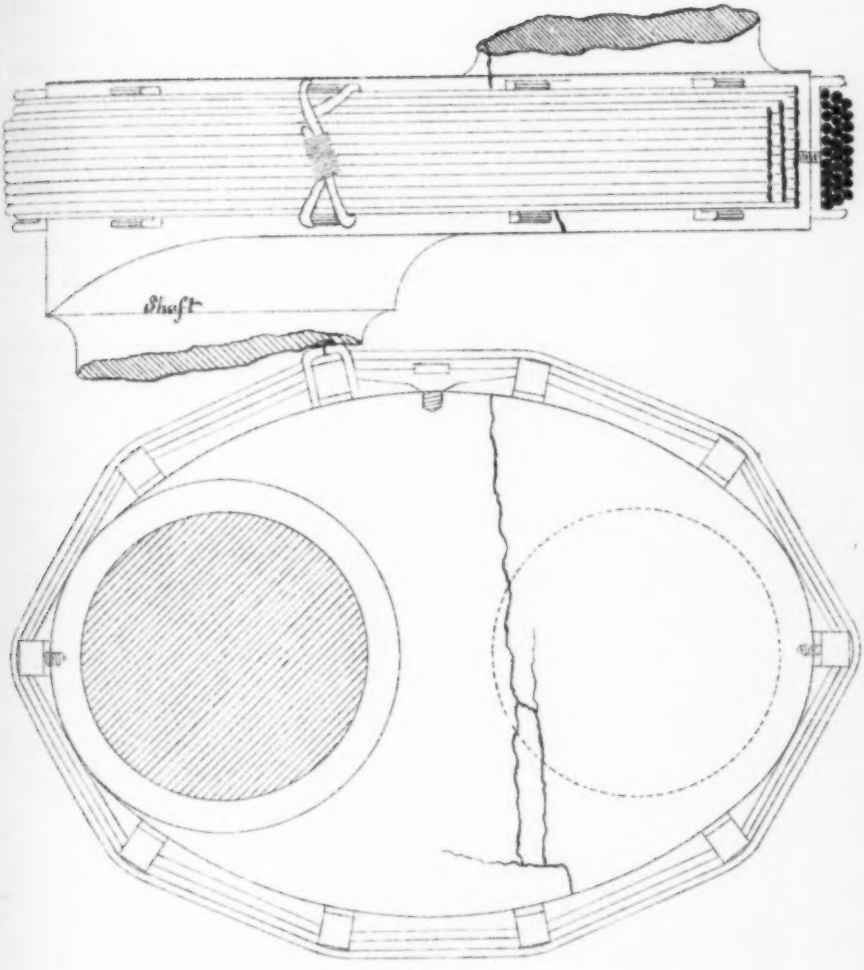
I expected that the wire rope would, in a short time stretch, and had intended therefore to first drive wedges under each shoe, nipping the ends over the edge of the crank, and then to drive all around, under the rope banding, dry pine wedges which would be swelled by the water used on the crank pins, but there was no necessity for any wedging up whatever, and perhaps would not have been, had the engines been in operation a much longer time than they were. The shape of these cranks made the application of the banding quite a simple matter, but

I apprehend it would not be very difficult to adapt such a system of wrapping with wire rope to a crank of any shape whatever.

I do not think the idea has occurred to engineers generally that they have in wire rope such a ready and effective means of temporarily repairing damages to engines at sea. Many repairs that are now made with straps or bands hastily constructed under the disadvantages always attending smith's work on board ship can be much more quickly and easily made by a few turns of wire rope. The ease and facility with which repairs can be made with wire rope commend it to engineers and steam ship owners as a part of the necessary outfit for steamships. This material may yet be the means of repairing the broken shaft of a steamer, so that she will be able to steam into port at a moderate rate of speed.

In the case of repairs to a broken shaft, the ends of the rope could be secured to the back of square pieces of iron, with holes to pass the rope through;—passing the turns around the shaft, and securing the other end to the other part of the shaft in a like manner; the square pieces to be recessed into the shaft as a key and secured by tap bolts to hold them securely to the shaft; for backing, there must be layers of rope wound around the shaft in the opposite direction.

J. C. KAFER, P. A. ENGNR., U. S. N.


Shaft

BOOK NOTICES.

Notices and reviews of professional publications may be inserted under this heading, provided a copy to be deposited in the library of the Institute is sent to the Corresponding Secretary. All reviews must be signed by the reviewer.

NAUTISCH-TECHNISCHES WÖRTERBUCH DER MARINE, *by P. E. Dabovich.* Published by the editors of the *Mittheilungen aus dem Gebiete des Seewesens*, Pola, Austria.

The Institute is indebted to the courtesy of the publishers for a copy of the sixth part of this nautical technical dictionary. According to the prospectus the first volume is to give the terms in German, Italian, French and English, and also in Italian, German, French and English. It is to be issued in about twelve parts (Lieferung) of eighty pages each at a cost of two marks each. In the preparation of this dictionary the latest naval works and the official publications of the naval departments of these countries have been consulted. In English, for example, some of the authorities cited are Capt. Nares on orthography of Naval terms; Reed, Rankin and White on naval architecture and machinery; Lloyd's Rules etc. The German and Italian words are introduced in alphabetical order and are distiguished from each other by the type, full-faced type being used for the German words and italics for the Italian. The typographical execution is excellent, the paper being good, the type clear and the form of the volume convenient. The field which this dictionary seeks to cover being comparatively narrow it admits of greater fullness, and on comparison we find that while this work devotes seventy-nine pages to words from El to Fr, von Albert's Technologisches Worten-buch gives but forty-three pages of the same size to this division. The rules of the road are given at length under their appropriate heads. It would be manifestly unfair for us to pass judgment upon the whole work from the part before us, yet we cannot refrain from calling attention to the fact that many of the English renderings while literal are not idiomatic, that numerous errors in orthography are committed, and that occasionally French words are used in English

sentences. Some examples of the first are der Hochofenguss rendered *Iron cast out of the high-furnace*; der verdächtige Gesundheitspass, *touched bill of health;* Fensterschiebe, *glass square*; Feuerwirkung, *performance of the fire*; die Eisentheile zur Leitung des Tauwerks, *iron works for leading the ropes*; and unter Hand fieren, *To ease off hand under hand.* Examples of the second errors are; *serge* of the cable; *afriction, pledgeds; heckled and speckless.* As this work must be of value to all English speaking officers it is to be hoped that the future parts may be revised by some officers, whose mother tongue is English, before publication.

ALMANACH FÜR DIE K. K. KRIEGS-MARINE, 1881. New series, 1st year. Published by the editors of the *Mittheilungen aus dem Gebiete des Seewesens; Pola.*

From the same source we have received a copy of this admirable little pocket book containing a register of the Austro-Hungarian navy, pay tables, extracts from the laws and regulations for the navy, tables, a formula for use in navigation and descriptions of the methods employed, useful tables upon the consumption of coal, the calorific power of coal, strength of material, dimensions of ships and machinery, electrical tables, tables of time, money, and measures, tables of the navies of the world and their armaments and armor, and many other useful tables making it a valuable pocket compendium. It is amusing to find at the end of the table devoted to the United States Navy, "that all data upon the American Navy is little to be depended on."

C. E. MONROE, PROF. U. S. N. A.

BIBLIOGRAPHIC NOTICES.

ARMY AND NAVY MAGAZINE, JAN., 1881. (Naval articles). The Russian Navy, the story of the cruisers. Naval artillery. The De Bay propellor.

MARCH, 1881. The Russian fleet in Central Asia.

COLBURN'S UNITED SERVICE MAGAZINE, JAN. 1881. (Naval articles.) The progress toward a written law of war. The Argentine armor-clad corvette Almirante Brown. *Critical Notices.*

FEBRUARY, 1881. The Atalanta report. The Russian Imperial yacht Livadia. Soldiers and sailors and their wills. *Editorial and critical notices.*

MARCH, 1881. The condition of our fighting forces, with suggestions. H. M. S. Resolute, a true story of the Arctic Regions. Shipping bounties. *Editorial Notes.*

COMPTES RENDUS. VOL. XCI, NO, 16. Admiral Mouchez commends the accuracy of Lt. Comdrs. Green and Davis, in their determinations, by telegraph, of some of the principal longitudes on the coast of Brazil. He was himself charged, in 1860, with the task of determining the hydrography of Brazil and La Plata. In the performance of his duties he made a large number of astronomical observations, which accorded so closely with previous records that he affirmed in his report that the longitudes were known with nearly as great accuracy as those of the great observatories of Europe. The French astronomers, however, discredited his results and adopted values about 30 seconds greater. The American observers have fully confirmed Moucez's assertions, showing that his greatest error was only 2.34 seconds, and in one case the error was only five-eighths of a second. Errors of from two to four seconds have been recently detected in the longitudes of some of the European ports. These comparisons also show the great precision with which longitudes can be ascertained by chronometers, when their rates are properly verified at the end of every voyage.

VOL. XCII. NO. 8. THE SOLAR PARALLAX. M. Faye communicates to the French Academy of Sciences an interesting paper upon the state of our knowledge of the sun's parrallax. Remarking that there is no other constant in nature whose determination depends upon so large a number of independent results, he classifies the various values assigned for the sun's mean parrallax a follows:

Geometrical Methods 8.82″	8.8[illegible]″	by Mars, (Cassini's method). Newcomb.
	8.78″	by Venus, 1769, (Halley's method.) Powalky.
	8.81″	by Venus, 1874, (Halley's method.) Tupman.
	8.87″	by Flora, (Galle's method.) Galle.
	8.79″	by Juno, (Galle's method). Lindsay.
Mechanical Methods 8.83″	8.81″	by the lunar inequality, (Laplace's methods). ——.
	8.85″	by the monthly equation of the earth. Leverrier.
	8.83″	by the perturbations of Mars and Venus. Leverrier.
Physical Methods 8.81″	8.799″	by the velocity of light (Fizeau's). Cornu.
	8.813″	" " (Foucault's method.) Michelson.

Faye concludes that the results obtained by the physical methods are more reliable than those obtained in any other way, and by adopting the results obtained by Master A. A. Michelson, U. S. N., in his determination of the velocity of light, the value of the solar parallax 8.813″ is now determined to within one hundredth of a second of arc.

EDINBURGH REVIEW. JAN. 1881. The Navies of the World.

JOURNAL OF THE ROYAL UNITED SERVICE INSTITUTION, NO. CVIII. (Naval Articles). The Nordenfelt machine guns (Palmcrantz's system.) *Occasional Papers.* On the several European Systems of Naval Education. Under the above title J. K. Laughton, R. N., Mathematical and Naval Instructor at the Royal Naval College reviews at length Prof. Soley's "Report on Foreign Systems of Naval Education." He says, "His investigations appear to have been thorough and searching, and the report which he rendered to the Secretary of the Navy, now published by order of the Senate of the United States, embodies more accurate and detailed information, as well as more intelligent criticism on the various systems of naval education, than has hitherto been rendered in any way availiable."

"Not unnaturally, the report begins with Great Britain; and, following carefully the several statements made as to matters of fact, we are struck with the remarkable accuracy of the whole: the very few errors that we have noticed are of the most trifling nature, entirely void of significance; and if we may take this first part as a guage of the merit of the other three, the work stands almost alone as an absolutely correct historical record. It is as such a gauge that we have used it. We do not propose to repeat here the minute details which Professor Soley has given of the English system of entry, of service, and of promotion; of education on board the "Britannia" in sea-going ships, and at the College at Greenwich. They cannot but be pretty well known to all readers of the Journal who are interested in the subject. But whilst thus omitting the facts, we think that the opinions which Mr. Soley has been led to form on the several points connected with our system are well worth reproducing, if only as the opinions of a singularly capable and well-informed foreigner free from the trammels of old custom and of national prejudice."

In a postscript Prof. Laughton notices the American system of education as deduced from the Official Reports of the Secretary of the U. S. Navy, from the Registers of the U. S. Naval Academy and from Prof. Soley's

Historical Sketch of the U. S. Naval Academy. His conclusions are "that the American system is singular in this; that nominations are given largely in excess of the requirements of the service; and that the nominees are ruthlessly thinned out by a test examination and a course of instruction beyond the capabilities of three-fourths of their number. Such a system must be exceedingly costly and excessively laborious; it must also tend to lower the standard not only of admission but of graduation; and though this latter—owing to the riper age of the cadets and the four years' close study at a college on shore—is somewhat higher than the obligatory course in our own Service, it would seem to compare unfavorably with that of either Germany or France. Whether a competitive examination for entry (as is held for the cadet-engineers), or for passing out, would not be more advantageous is a question which naturally occurs to us, but which probably political motives have led the American Representatives to answer in the negative. *Reviews and Book Notices.* "The War Ships and Navies of the World" by Chief Eng. J. W. King, U. S. N. "Navies of the World" by Lieut. E. W. Very, U. S. N. Mr. King is already known to English readers. Two years ago a volume by him on the 'War Ships of Europe,' was published in his own country and republished in this. His present work comprises a survey of every navy in the world. It is to a great extent composed of extracts from English newspapers such as the Times, Engineer, Broad Arrow, et cet. He has also included in it a good deal of information derived from official sources and foreign publications. The book is a valuable one. It is usually very accurate, and is well illustrated. Lieut. Very's work is—as far as ships are concerned—less full than the foregoing. Its illustrations are rather rude and many of the figures hardly exact. But in the part devoted to the armaments of naval States is to be found much information which is, probably, not collected in any other single volume." *Prize Essay Notice.*

MITTHEILUNGEN AUS DEM GEBIETE DES SEEWESENS. VOL. IX. No. I. The use of Austrian steel in shipbuilding. Report of the commission upon the bursting of the 45cm. Armstrong gun on board the Duilio. Description of foreign woods used in the Austrian Dockyards. The relative value of guns. Breech-loaders for the U. S. Navy. Production of steel for guns, in Woolwich. Artillery committees in England. Repeating rifles. Discharging apparatus for fish torpedoes, by H. Chapman. Protection for torpedo boats against mitrailleuses. The Destroyer. New discharging apparatus for fish torpedoes. Compound armor plates in England. Trial trips of the Russian gunboats Doid and Wichr. New vessels for the French Navy. Trial trip of the U. S. Mercury. Building and trial of H. M. Transport Sea-horse. Trial of the Artillery and machinery of the Inflexible. Notes on the English Navy. Smaller iron-clads for the Italian Navy. The relation between the French merchant marine and the French Navy. *Literary Notices. Hydrographic Notices.*

NAUTICAL MAGAZINE. JANUARY, 1881. The weather of the autumn, Sept.—Nov., 1880. Signalling by means of sound. Grain Cargoes. The

new regulations for preventing collisions at sea. Physical examination of pilots and seamen in the United States. *Correspondence. Marine Inventions et cet.*

FEBRUARY, 1881. The stability of the Atalanta. The Atalanta Enquiry. Hydrographical surveys. Minihoi Island. Rotumah Island. Navigation of the Mersey. Decay of American Shipping. *Marine Inventions, et cet.*

MARCH, 1881. Thames pilotage. French merchant shipping bill. Seas between China and Japan. Madras harbor and the proposed canal across the Malay Peninsula. The contagious diseases act. *Correspondence, et cet.*

REVISTA GENERAL DE MARINA. JANUARY, 1881. Notes on electricity (continued). Voyage of the "Marques Del Duero" to Siam and Annam (continued). Relative importance of broadside and fore-and-aft fire, in naval tactics (concluded). Notes on the arrangement of the electric light on board the frigate Sagemto. Naval Tactics on the open sea, with the existing types of vessels and weapons, (Naval prize essay). Translated from the Journal of the Royal United Service Institution). Operations of the Chilian squadron before Callao. Difference between the temperature of the air by the thermometer and by sensation. The Spanish Society for saving the shipwrecked. Notices. *Orders. Movement of Ships.*

FEBRUARY, 1881. Notes on electricity (continued). Voyage of the "Marques Del Duero" to Siam and Annam (continued). Guide for manœuvres in a hurricane. Economical stores in ships of war. Reform in the colony of Fernando Po. Naval Tactics on the open sea, with the existing types of vessels and weapons. (Naval prize essay. Translated from the Journal of the Royal United Service Institution). Shipwrecks on the coasts of Spain. Marine life saving Remarks upon the experiments of the Aragon. Notices. *Orders. Movementr of ships.*

MARCH. Notes on electricity (continued). Voyage of the "Marques Del Duero" to Siam and Annam (continued). Game of Naval Warfare (translation). Remarks on the use of torpedo boats, (Translated from the Mittheilungen a. d. Gebiete d. Seewesens). Plating of steel surface for iron clads. Physical geography of the sea. The military arsenal at Shanghai. The Parlador of Lieut. Pinto.' *Notices. Orders. Movements of Ships.*

REVUE MARITIME ET COLONIALE. VOL. 67. 1880. The rolling and pitching of ships. New South Wales. De la Bourdonnais' expedition in the Indian Ocean, in 1746. The merchant marine in England. Determination of the longitude at sea by the method of equal altitudes. English colonies; Leeward, Virgin and Windward Islands. The rôle of artillery in fleet engagements. Statistics of the sea fisheries. China and Japan. The Barometric depressions in Europe, from July, 1877 to Jan. 1880. The naval war between Peru and Chili. *Notes. Bibliography.*

Proposed ship canal from the Atlantic to the Mediterannean. A family in the navy in the 18th century; Beaussier de l' Isle. Helicoidal propellers. Notes on waterspouts. English colonies; Trinidad and English Guiana. Notes on ramming by ships. Directions for avoiding cyclones. The hurricane dromoscope; an instrument for indicating graphically the course to be taken in a cyclone. *Reviews. Bibliography.*

The Pilcomayo; water route from Bolivia to the Atlantic. Note on the Sextant. The Scotch herring fishery, in 1880. Gareis' universal compass, translated from the Meittheilungen a. d. Gebiete d. Seewesens. The sham torpedo fights in England; translated from the Times. The relation between the true velocity of the waves and that observed on board a vessel under way. *Notes. Reviews. Bibliography. Index.*

RIVISTA MARITTIMA. JAN. 1881. The new naval constructions of the Italian Navy, Part II. Military sea-ports; Constantinople, from the *Organ der Militär. Wissenschaftlichen Vereine.* Administative regulations in regard to seamen of the Italian Navy. Naval warfare with the present types of ships and weapons; translation of the discussion in the Royal United Service Institution. The British Merchant Marine. The cellular system of construction for merchant vessels; translation of a paper read before the Institution of Naval Architects. The harbor of Montenegro. Torpedo-boats. The regattas of the *Societa dei Canottieri,* at Palermo. *Notes. Ships in the Italian Navy, Jan.* 1, 1881. Circular of the Italian Geographical Society. Notice in reference to the third International Geographical Congress, to be held at Venice in 1881. Collection of Italian periodicals at the Milan exposition. *Transfers of Officers. Officers of ships in commission.*

FEBRUARY, 1881. Fleet engagements in the future. The enrolment of seamen. The decline of the Italian merchant marine. The changes in the merchant marine, and the re-organization of Italian commerce. Notes on the construction of yachts. Extracts from English consular reports. A letter of Columbus, written to Sanchez, in 1493; with a notice. *Notes. Bibliography. Transfers of Officers. Ships in commission.*

MARCH, 1881. The ancient and the modern ram. Colonies and emigration. Italian consul at the Piraeus. The relation between the true velocity of waves and that observed on board a ship under way, translated from the French. The elements of naval tactics. The micro-telephone of Ader, and experiments on the Turin-Ciriè-Lanzo telegraph. Krants's method and tables for the determination of lunar distances. Bayer's diagram for determining elevations and distances at sea. Italian shipping at Fiume. Extracts from English Consular Reports. John and Sebastian Cabot. Trinity House Rules upon Buoys and Beacons. *Notes. Bibliography. Various Publications. Transfers of officers. Ships in commission.*

WESTMINISTER REVIEW. JAN. 1881. The progress of ship building in England.

BOOKS RECEIVED.

American Geographical Society, Bulletin No. 2 of 1880.

American Society of Civil Engineers, Transactions, Jan., Feb., 1881, and List of members.

American Society of Mechanical Engineers. Papers read at First Annual Meeting, Nov., 1880, and List of members.

Architecture Navale—Carènes Rapides. By A. Wazon, Paris.

Franklin Institute, Journal. Jan., Feb., Mar., and supplement, 1881.

Institution of Mechanical Engineers, Proceedings, Aug., 1880.

Mittheilungen aus dem Gebiete des Seewesens, Nos. XI and XII of 1880, and I of 1881. Almanach-für die K. K. Kriegs-Marine, 1881; new series, first part. Nautisch-techniches Worter-buch der Marine, by *P. E. Dabovich.*

Rivista Marittima. Jan., Feb., Mar., 1881.

Royal United Service Institution, Journal. No. CVIII.

Societé des Ingenieurs Civils, Memoires. Dec., 1880, Jan., 1881.